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Effects of Single-sex Classrooms Versus Coeducational Classrooms on Math and Literacy Achievement

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EFFECTS OF SINGLE-SEX CLASSROOMS VERSUS COEDUCATIONAL CLASSROOMS ON MATH AND LITERACY ACHIEVEMENT

by

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DEDICATION

I would like to dedicate this degree and research project to the glory of God. All knowledge and power comes from Him. His wonderful power was made clear to me as I studied learning differences between the genders. I do not know what implications this dissertation will have in the future, but I put this work and my future in God's hands. I pray that this project will be used in some way to further His kingdom.

ABSTRACT

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Title: Effects of Single-sex Classrooms Versus Coeducational Classrooms on Math and Literacy Achievement (Under the direction of Dr. Michael Brooks)

This research project was designed to add to the limited available research concerning the effectiveness of single-sex education within a public elementary school setting. Following the first year of implementation of a single-sex classroom pilot program, the effects by gender of classroom grouping (single-sex education versus coeducation) on reading and math achievement were investigated for three consecutive grade levels from second grade through fourth grade.

This causal comparative study was conducted in a rural school district in Northwest Arkansas with a total student population of approximately 3,800 students from kindergarten through 12th grade. Reading achievement was measured using reading-comprehension scaled scores from the SAT-10, and math achievement was measured using math problem-solving scaled scores from the SAT-10.

The sample for this study included matched pairs of students from single-sex classes and coeducational classes. The researcher used pairs of students who were matched by grade level, gender, socio-economic status, and previous year's performance levels (below basic, basic, proficient, and advanced) in both literacy and math.

A 2 x 2 factorial ANOVA was used to analyze the data collected for each of the six hypotheses. The results of this study showed no significant interaction effects between students participating in coeducational classrooms and those participating in single-sex classrooms by gender for the six hypotheses. In addition, the study found no significant main effect of type of classroom through the hypotheses. However, a significant gender difference, favoring boys, was seen in second grade math, and a significant gender difference, favoring girls, was seen in third grade literacy.

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CHAPTER 1

INTRODUCTION

Today's classroom consists of students with a variety of specific needs such as special education students, English Language Learners (ELL), and a range of ethnic and cultural backgrounds. Educators today must provide classroom experiences that address the needs of a variety of learners. Yet, the most fundamental of all student differences are differences based on gender. Recently, brain research has brought to light gender differences that include much more than the obvious physical differences between genders. These differences directly affect the learning process and classroom instruction (Gurian, Stephens, & Daniels, 2009; Sax, 2005).

Current research and legal changes have educators considering the possible benefits of single-sex classrooms to address specific gender differences and learning needs. Researchers have studied the pros and cons of single-sex education versus coeducational education with mixed results (Sather, 2009). Positive effects result from single-sex classrooms in about one-third of the studies, with about one-half of the studies showing no significant difference between single-sex classrooms and coeducational classrooms in the area of student achievement. Heated debate and controversy surround the topic of single-sex classrooms with some women's groups and the American Civil Liberties Union (ACLU) believing that the very idea of single-sex education means discrimination (Fagan, 2008; "Grade schools test," 2006). Proponents, however, point to

the benefits of single-sex classrooms that include increased student achievement and self-esteem (Pytel, 2006). Benefits are specifically seen when teachers have had professional development to support their understanding of gender differences (Gurian & Ballew, 2003; Sax, 2005). Other benefits have included decreased discipline problems and decreased absenteeism.

Although No Child Left Behind legislation changes in 2002 opened the door for public schools to offer single-sex classrooms, several restrictions must be met. Classes must be geared toward improving student achievement, meeting the needs of students, treating males and females equally, and enrolling students on a volunteer basis. The National Association for Single-Sex Public Education (n.d.c) reported 540 schools in the United States supporting single-sex education. Ninety-five of these schools would be considered single-sex schools, and the others would be schools offering single-sex classrooms. These schools do not include juvenile detention centers that provide single-sex education.

Statement of the Problem

The purposes of this study were six-fold. First, the purpose of this study was to determine the effects by gender of classroom grouping (single-sex versus coeducational) on math achievement for second grade students in a Northwest Arkansas school district. Second, the purpose of this study was to determine the effects by gender of classroom grouping (single-sex versus coeducational) on reading achievement for second grade students in a Northwest Arkansas school district. Third, the purpose of this study was to determine the effects by gender of classroom grouping (single-sex versus coeducational) on math achievement for third grade students in a Northwest Arkansas school district.

Fourth, the purpose of this study was to determine the effects by gender of classroom grouping (single-sex versus coeducational) on reading achievement for third grade students in a Northwest Arkansas school district. Fifth, the purpose of this study was to determine the effects by gender of classroom grouping (single-sex versus coeducational) on math achievement for fourth grade students in a Northwest Arkansas school district. Sixth, the purpose of this study was to determine the effects by gender of classroom grouping (single-sex versus coeducational) on reading achievement for fourth grade students in a Northwest Arkansas school district.

Background

Historical

Until recently, the concept of single-sex education was not a possibility in public education. In 1972, Title IX regulations prohibited discrimination based on sex in public education programs. Again in 1975, the Department of Health, Education, and Welfare issued Title IX regulations that barred single-sex classrooms or programs. Recently, however, the No Child Left Behind (NCLB) legislation of 2002 opened the door to allow public schools the opportunity to look at new and innovative educational ideas including single-sex education. At this time, the United States Department of Education began revising Title IX provisions to make it easier for schools to adopt single-sex classroom policies (Cable & Spradlin, 2008).

This renewed interest in single-sex education has also been spurred on by recent brain research. Authors such as Sax (2005) and Gurian & Ballew (2003) have identified several physical differences between males and females that affect learning and classroom instruction, such as differences in hearing and vision. They note that girls have

substantially more sensitive hearing than boys do. Boys also have a thicker retina, which allows them to see things from the standpoint of movement, and girls see things as objects and take note of the characteristics of those objects. This can best be seen when students are given free draw opportunities. Girls will typically draw people, places, and things, and boys will typically draw action scenes. Both authors also note that at an early age the female brain is quickly developing verbally and linguistically, and the male brain develops more rapidly in the area of spatial sense during the same developmental period. In the area of language processing, boys tend to have their language processing areas in the left hemisphere of their brains, and girls tend to have multiple language processing areas in both hemispheres allowing girls more resources to develop language earlier than boys (Gurian et al., 2009). It is important to note that these are gender generalizations, and they are not indicative of each individual and unique student but instead indicative of the tendencies of each gender as a whole. However, there is enough research to testify to the fact that these gender tendencies exist.

> In light of this, we think that it is admissible to recognize that, although boys are not an undifferentiated group, there are broad similarities within sub-groups which allow us to make valid generalizations, and within this, if we compare similar groups of boys with similar groups of girls, we can confidently point to evidence of lower levels of academic attainment by boys. (Younger & Warrington, 2005, p.19)

If teachers do not understand these differences, they typically teach the way either that they have been taught, or they use methods that meet their personal gender style. Single-

sex education allows teachers to gear more classroom activities and instruction toward the needs of one or the other gender tendencies.

Learning Differences in Girls

Gurian, Stevens, and Daniels (2009) note that girls are typically able to process more sensory data than boys are, which in the classroom translates to being able to provide more detail in their writing. They are more likely to enjoy a quiet classroom environment and like to work cooperatively. Girls are also more likely to try new things when boys are not around, especially things that are considered areas that typically interest boys. The corpus callosum that connects the two hemispheres of the brain tends to be denser and larger in the female brain allowing girls to be better at multitasking and being able to process information quickly by using both sides of the brain.

Learning Differences in Boys

On the other hand, boys are spatial and require more room to work (Gurian et al., 2009). They thrive on competition, and they might be more comfortable working on the floor or standing than sitting at a desk. The corpus callosum in boys is less dense so that the cross talk between the two hemispheres of the brain does not happen as quickly in boys as it does in girls. This translates to the fact that boys need more time to process information and emotions. A teacher in an all boy classroom would need to allow for lots of movement and give a longer wait time when asking questions.

Gender and Achievement Concerns

In the 1970s and 1980s, issues arose concerning the fact that girls were not doing as well as boys in the areas of math and science. Recently, there has been a concern that boys are falling behind in literacy and are being over identified for hyperactivity

disorders and special education (Sax, 2005). “Scores on the main assessment of the National Assessment of Educational Progress (NAEP) reveal that, across all three grades, females have consistently outperformed males in reading since the early 1900’s” (U.S. Department of Education, 2004, p. 28). One of the problems might be that today’s classroom environment is not set up to meet the differentiated learning needs of boys and girls (Garibaldi, 2006; Mead, 2006; Sax, 2005). Both the statement that girls are underachieving in math and science and the statement that boys are lagging behind in literacy have caused alarm at a national level. However, the issue is not as bleak as the picture has been painted (Hyde, Lindberg, Linn, Ellis & Williams, 2008). A U.S. Department of Education (2004) report, entitled *Trends in Educational Equity of Girls & Women: 2004,* states that gender differences in mathematics on the NAEP assessment “have been quite small and fluctuated only slightly between 1900 and 2003” (p. 30). The issue is not that girls are poor math and science students or boys are poor literacy students. Studies have shown that when these subjects are taught from the gender perspective, more students are able to comprehend the material being taught (Gurian & Ballew, 2003; Sax, 2005).

Current Trends

The idea of single-sex education is not a new idea. The first single-sex schools in the United States were established to educate boys (Meyer, 2008). Eventually, schools were established to educate women. Single-sex education, however, has been more often found in private schools, accessible only to those wealthy enough to afford the tuition. Those attending single-sex private schools talk about the benefits of learning in same-sex learning environments without the distractions provided by coeducational classrooms

(Younger & Warrington, 2005). Extending the single-sex classroom experiences to public school is a recent phenomenon. However, according to Senator Hillary Clinton:

> There should not be any obstacles to providing single-sex choice within the public school system. We should develop and implement quality single-sex educational opportunities as a part of providing a diversity of public school choices to students and parents. Our long-term goal has to be to make single-sex education available as an option for all children, not just for children of parents wealthy enough to afford private schools (National Association for Single-Sex Public Education, n.d.b, para. 5).

A review of literature reported several benefits to single-sex education. Single-sex classrooms allow students to learn in an environment free from other sex distractions and concentrate on academic performance instead of social interaction (Hughes, 2006; Younger & Warington, 2005). Other benefits are gender specific. In single-sex classrooms, girls are comfortable asking questions in class; they are at ease answering questions; and they are contented in a relaxed atmosphere. They also enjoy the social aspect of working with others. Boys, on the other hand, thrive in a competitive environment, like action-based lessons, and they benefit from time restraints on tasks (Pytel, 2006). Another positive aspect of offering single-sex public education is to allow parents and students educational learning environment choices.

Research Studies

Research concerning single-sex education has yielded mixed results (Jenkins, 2006). In the area of student achievement, studies have shown to either slightly favor single-sex education (Hopkins, 2001; Meyer, 2008; Sharpe, 2000) or be neutral (Friend,

2006; Gillis, 2005) for student achievement when compared to coeducational schools. A review of research done by the Mael, Smith, Alonso, Rogers and Gibson (2004) for the American Institutes for Research found that roughly one-third of the studies favored single-sex schools in terms of short-term achievement. Spielhagen (2008) states, "If test scores are the benchmark, then the results of this study suggest that single-sex classes work for some students in some classes, but do not guarantee increased achievement performance on standardized tests" (p. 66). In addition, other issues such as student self-confidence and attitude toward school slightly favor the single-sex environment. Some research studies indicate that minority and low socioeconomic students benefit most from a single-sex environment when the teacher focuses on gender specific learning style differences (Hughes, 2006). The problem with the current research is that there are few good quantitative research studies on single-sex education, and most of the research has been done in private secondary and post-secondary settings with very little research done on public schools. In addition, there are few studies of elementary classrooms (U.S. Department of Education, 2005; American Institutes for Research, 2004).

Research Hypotheses

The brief review of literature indicated mixed results concerning the effects of single-sex education on student achievement. In addition, few research studies have looked at student achievement effects within an elementary public school setting. Therefore, the researcher generated the following hypotheses. First, no significant difference will exist by gender between second grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement. Second, no significant difference will exist by gender

between second grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement. Third, no significant difference will exist by gender between third grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement. Fourth, no significant difference will exist by gender between third grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement. Fifth, no significant difference will exist by gender between fourth grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement. Sixth, no significant difference will exist by gender between fourth grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement.

Description of Terms

Coeducation classroom. A coeducation classroom is a classroom where the learning environment consists of an integration of male and female students. Coeducation is also known as mixed-sex education.

English Language Learners (ELL) students. ELL students are students whose primary language is one other than English. There are several different levels of ELL students ranging from level one to level five depending on a student's grasp of the social and academic language. The levels are measured through the use of the English Language Development Assessment (ELDA) (Arkansas Department of Education, n.d.).

Literacy achievement. Literacy achievement is measured by a reading comprehension scaled score as measured by the 10th edition of the Stanford Achievement Test (Pearson Education, 2004). The Stanford Achievement Test is published by Pearson Assessment & Information. Arkansas has purchased the tenth edition of the Stanford Achievement Test to meet the student assessment requirements of the U. S. Department of Education's No Child Left Behind legislation (Arkansas Department of Education, n.d.).

Math achievement. Math achievement is measured by a total math scaled score as measured by the 10th edition of the Stanford Achievement Test (Pearson Education, 2004). The Stanford Achievement Test is published by Pearson Assessment & Information. Arkansas has purchased the tenth edition of the Stanford Achievement Test to meet the student assessment requirements of the U. S. Department of Education's No Child Left Behind legislation (Arkansas Department of Education, n.d.).

Low socioeconomic students. For this study, low socioeconomic students are defined as students who qualify for either the free or reduced cost lunch program as described in the National School Lunch Act. The National School Lunch Act is overseen by the United States Department of Agriculture.

Stanford Achievement Test 10th edition (SAT-10). The SAT-10 is a standardized assessment for students in Kindergarten through the twelfth grade (Pearson Education, 2004). The SAT-10 provides a vertical scale that allows for the evaluation of student progress over a period of years (Jorgensen, 2004).

Single-sex classroom. A single-sex classroom is a classroom where male or female students attend class exclusively with students of the same gender. This classroom

grouping is primarily for teaching the core subject areas of math, language arts, reading, science and social studies. The teacher may or may not be of the same gender as the students in the class.

Single-sex education. Single-sex education can be either schools or classrooms where male or female students attend school exclusively with those of the same gender. The teacher may or may not be the same gender as the students in the class.

Significance

Research Gaps

"There is a dearth of quality studies" on single-sex schools according to a U.S. Department of Education (2005) meta-analysis study of single-sex schools (p. 87). This study also mentions, "Too few researchers report descriptive statistics or effect sizes" (p. xvii). Research suggests that future studies need to be done in schools with high minority and high poverty rates (Cable & Spradlin, 2008). In addition to the small number of research studies available in the broad area of single-sex classrooms, the research that has been done has been skewed toward particular topics leaving certain aspects of single-sex education under-researched. Much of the current research has been conducted in middle schools or high schools with more of a concentration on girls than boys. The effects of single-sex education in the elementary school and programs involving boys warrant more attention (Kasic, 2008). Current research on single-sex education lacks both quantitative research and research in done elementary settings. This study will provide quantitative research on the effects of single-sex classes in an elementary setting addressing two of the gaps noted in the review of literature. The study will also address the lack of studies involving boys by monitoring the academic achievement of both boys and girls.

Legal issues cause part of the problem in doing true experimental research on single-sex education because legally, students have to volunteer for single-sex classes and therefore cannot be randomly placed in a single-sex environment. However, given the conditions that must be followed legally, more stringent controls need to be taken within research studies being conducted, collecting both quantitative and qualitative data.

Public School Choice Options

School vouchers are being heavily debated today as a way to allow students educational choice. However, vouchers have not shown to improve student achievement (McDonald, 2002). The issue remains that parents and students want educational choice. Brandt (2002) states the need for public schools to look for ways to diversify learning within the public school to offer students and parents more choice. Single-sex classrooms are one way of diversifying. Implementing a single-sex classroom program is also an economical way of providing students classroom choice within the public school setting. Schools, teachers, parents and students want to make good research-based educational choices. The results of this study can have an impact on Arkansas as the state provides schools with information concerning viable, productive, and economical ways to offer educational choice within the public school setting.

Process to Accomplish

Design

A causal comparative study was conducted in a rural school district in Northwest Arkansas with a total student population of approximately 3,800 students from kindergarten through twelfth grade. The independent variables for all six statements of the problem were type of classroom environment (single-sex versus coeducational) and

gender (male versus female). The dependent variable for statements one, three, and five was the measured math achievement represented by a scaled score on the SAT-10. The dependent variable for statements two, four, and six was the measured reading achievement represented by a scaled score on the SAT-10.

Sample

During the 2009-2010 school year, two of the five schools in a rural Northwest Arkansas school district implemented a program for single-sex classrooms. The schools in this district are grade level specific with all students from each grade attending the same school. The study included second grade students housed in one elementary school, and third and fourth grade students housed in another elementary school. At each grade level two male and two female classrooms with between 23 and 27 students each were established with the rest of the classrooms at each grade level being coeducational. The single-sex classroom students participating in this study were selected from a group of students whose parents expressed an interest in having their child participate in a single-sex classroom. The demographics of the students participating in the single-sex program reflected the demographics of the district as a whole. Approximately 55% of the students within the district qualified for either free or reduced lunch rates classifying them in a low socioeconomic category. An attempt was made to provide a socioeconomic balance within the single-sex classrooms that was representative of the district as a whole. Overall, 49% of the students participating in the single-sex classes qualified for either free or reduced lunch rates classifying them in a low socio-economic category. A variety of ability levels were included in each classroom from students identified as gifted to students identified with special needs.

Using Excel, students were grouped by gender, classroom placement, socio-economic status, and state designated literacy and math proficiency levels from the results of the 2009 SAT-10 and Arkansas Augmented Benchmark Exam. Students in the single-sex classrooms were then matched with students in coeducational classrooms. Each coeducational student included in the study was an exact match to a student in the single-sex classes by grade, gender, socio-economic status and state designated proficiency levels based on the literacy and math sections from the 2009 administration of the SAT-10 and Arkansas Augmented Benchmark Exam.

Twelve teachers volunteered to teach in the single-sex classrooms as part of a pilot program to introduce the concept of single-sex classes. Ten of the teachers were female and two were male. The two male teachers taught all boy classrooms, one in the third grade and one in the fourth grade. All teacher volunteers expressed interest in learning more about single-sex classroom strategies and were provided with two books, *Why Gender Matters* (Sax, 2005) and *Strategies for Teaching Boys & Girls Elementary Level* (Gurian, Stevens, & King, 2008), to read during the summer. All but one of the single-sex classrooms teachers participated in a one-day professional development workshop provided by the Gurian Institute that provided background knowledge and a research base concerning gender differences and teaching strategies to address gender specific student needs. Single-sex classroom teachers were also provided with the email addresses of teachers in several Florida elementary schools that had been teaching in a single-sex classroom environment for several years. The Florida teachers provided support for the single-sex classroom teachers during this implementation year by becoming email partners.

Both single-sex classroom teachers and coeducational classroom teachers were offered reading material and training in understanding and supporting gender-based learning differences in the classroom. All teachers were offered training in gender-based learning differences to try to minimize the Hawthorne effect on the single-sex classes seeing themselves as being treated in a special way. The purpose of training all teachers was to allow the study to focus more on the single-sex environment versus the coeducational environment instead of comparing teachers that understand gender-based learning styles and those that do not.

Instrumentation

Scaled scores from the SAT-10 were used to measure math and reading comprehension. The test was administered to all students in the spring of 2010. In the third and fourth grades, the SAT-10 was part of an augmented state test administered to all third and fourth grade students in the state. The SAT-10 is a nationally recognized test that allows educators to assess student progress. According to Statistics Solutions, Inc. (2009), the Reading section of the SAT-10 received an alpha reliability rating of .87 and the Math section between .80 - .87.

The SAT-10 is a norm-referenced standardized assessment. This test was administered in the spring of 2010 using standardized testing procedures. Pearson Education scored the assessments and the scores were sent to the district. The Reading Comprehension subtest was used to measure students' ability to comprehend reading literary, informational, and functional texts. The students read each selection and then answered a series of questions pertaining to the selection. The mathematics problem solving subtest measured students' ability to solve problems within each of the National

Council of Teachers of Mathematics categories of number sense and operations, algebra, geometry, measurement, data analysis and probability.

Data Analysis

The results of the SAT-10 achievement test were compiled, and appropriate statistical tests were conducted to accept or reject the hypotheses that were formulated. To address the first, third, and fifth hypotheses, 2 x 2 factorial analysis of variances (ANOVAs) were conducted using classroom type (single-sex versus coeducational) by gender (male versus female) as independent variables and math achievement as the dependent variable for the three different grade levels, second, third, and fourth, respectively. To address the second, fourth, and sixth hypotheses, 2 x 2 factorial ANOVAs were conducted using classroom type (single-sex versus coeducational) by gender (male versus female) as independent variables and literacy achievement as the dependent variable for the three different grade levels, second, third, and fourth, respectively. To test the null hypotheses, a Bonferonni adjustment was used to modify the alpha level from .05 to .025 to correct for alpha inflation because each of the samples was tested twice. The stricter alpha level will help control for Type 1 errors (Pallant, 2007).

CHAPTER II

REVIEW OF RELATED LITERATURE

Educators are always searching for ways to make learning meaningful and relevant for students. However, what makes learning relevant for one student does not always make it relevant for the next student. Brandt (2002) advocates for schools to offer parents and students choice in curriculum and instructional strategies in order to meet the needs of all students. Recent brain research has brought to light differences in the learning processes between girls and boys (Cahill, 2005; Gurian & Ballew, 2003; Jensen, 2008; Sax, 2005). In light of the physical and chemical differences between the brains of boys and girls, the question has been raised concerning the possibility of better meeting the needs of boys and girls by educating them in single-sex environments or at least offering students a choice of being a part of a single-sex classroom. Recent legislation, including No Child Left Behind in 2002 and Title IX revisions in 2006, has supported the idea of providing students and parents with a choice of learning environments (Cable & Spradlin, 2008). Overall, Skelton and Francis (2003) note that in light of what is known about gender differences, teachers somehow need to take an active role in interventions.

History of Single-Sex Legislation

Since legislation was passed in 2006 to allow public school districts to offer students a choice of coeducational or single-sex classrooms, there has been a great surge of interest in single-sex classrooms (National Association for Single-Sex Public

Education, n.d.a). Schools implement single-sex classes for a variety of reasons including increasing student achievement, increasing positive behaviors, and increasing educational choice (Jenkins, 2006; Kasic, 2008; Martino, Mills, & Lingard, 2005; Salmone, 2003). As of February 2010, the National Association for Single-Sex Public Education (n.d.c) stated that there are at least 540 public schools across the nation offering single-sex classes. One state, South Carolina, has even appointed David Chadwell to the position of state-level Director of Single-Sex Education (South Carolina Department of Education, n.d.). Many gender studies have been done abroad, but not enough research has been done in the United States since the Title IX regulations were revised and published in 2006 to see if the single-sex classes are making a difference. A U.S. Department of Education (2005) study reviewed research on single-sex versus coeducational classes and decided that there was not enough qualitative research being done on this topic to be able to make any definitive statements about the positive or negative effects of single-sex classes on student achievement. The current available research has yielded mixed results.

Brain Research

General Brain Information

According to some researchers, a fully developed brain is made up of three parts the cerebrum, the limbic system, and the brain stem (Gurian & Ballew, 2003; Sousa, 2006). Others such as Jensen (2008) who describes the brain in four parts organize the parts of the brain in different ways. Each part of the brain has a specific function, but they also constantly work together. The cerebrum of the brain consists of a left and a right hemisphere. Four lobes make up the two hemispheres including the frontal lobe, the occipital lobe, the parietal lobe, and the temporal lobe. Recently, scientists have been able

to understand more about how the brain works using new technology. Computerized Axial Tomography and Positron Emission Tomography scans have been helpful in understanding the brain's structure; Electroencephalography, Magnetoencephalography, Positron Emission Tomography, Magnetic Resonance Imaging Functional Magnetic Resonance Imaging, and Functional Magnetic Resonance Spectroscopy technologies have been helpful in understanding how the brain functions (Gurian et al., 2008; Jensen, 2008; Sousa, 2006). These technologies have allowed scientists to watch the brain and identify which parts of the brain are being utilized when a person completes a specific task.

The brain stem is the most primitive part of the brain (Gurian & Ballew, 2003; Jensen, 2008; Sousa, 2006). It is located at the bottom of the brain and connects the brain to the spinal cord. This part of the brain monitors all of the unconscious behaviors such as breathing and heart rate. This area of the brain tells people to react when they are in danger prompting a fight-or-flight reflex. Of the body nerves, 11 out of 12 end in the brain stem.

The brain system that processes and stores emotions in the memory is made up of two parts: the upper and the lower limbic systems. The brain gathers sensory data, and the limbic system processes the information and provides an emotional response to the stimuli. The structures that make up the limbic system are the thalamus, the hypothalamus, the hippocampus, and the amygdala. Most of the structures in the limbic system are mirrored in the two hemispheres of the brain. Researchers now say that emotions play a big part in what information is stored for long-term memory (Sousa, 2006).

The cerebrum is covered by the cerebral cortex, which is the area in the brain where most of the thinking occurs (Gurian et al., 2009; Sousa, 2006). The cerebrum is composed of two hemispheres denoted as the left and right hemispheres each containing four lobes that are mirrored in each hemisphere. The frontal lobes control thinking, planning, and short-term memory. The temporal lobes control hearing, object recognition, long-term memory, and speech. The occipital lobes control vision, and the parietal lobes are responsible for calculations and spatial orientation. Although the lobes are found in both hemispheres, generally speaking, the left hemisphere is linked with verbal skills, and the right hemisphere is linked with spatial skills (Jensen, 2008). Verbal skills include reading, writing, and speaking. Spatial skills include directions, working with shapes, and measuring. In terms of learning, the left hemisphere is related to literacy skills, and the right hemisphere is linked with mathematical skills (Gurian et al., 2009).

Another important area of the brain is the cerebellum, located just below the rear of the cerebrum, behind the brain stem. The function of this part of the brain is to coordinate movement. Memory of movement may also be stored here allowing a person to rehearse movement mentally without actually performing that movement (Jensen, 2008; Sousa, 2006)

Jensen (2008) describes the initial functioning of the brain. When new information enters the brain, it goes to the thalamus, which serves as a router to the rest of the brain. Visual signals are then sent to the occipital lobes, language input is sent to the temporal lobes, and any perceived threats are sent to the amygdala. New information is filtered and is processed in the frontal lobes. If the information warrants more attention, it is sent to the hippocampus. If at some point the brain deems the information worthy of

remembering, it is organized and stored in the cerebral cortex. The brain can quickly process and categorize new information, but the process of storing the information to long-term memory can vary from hours to weeks.

Jensen (2008) noted that the movement of stimuli from one place to another in the brain occurs through brain cells. Axons, neurons, and dendrites are the three parts of the brain cell responsible for transmitting information from one cell to another. The stimulus is received by the axon; it then travels along the dendrite and is transmitted to the dendrites of another cell. The axon conducts electrical impulse information and transports chemicals. Myelin is a fatty lipid substance that forms around axons. The thicker the axon and the more myelin present, the faster the axon can process. Hormones such as progesterone and testosterone can also have an influence on the processing speed. The increased presence of adrenaline, which can occur during competition, can speed up processing time. Amen (2005) notes that the brain never rests. Even at night, the brain remains active, especially while dreaming.

Gender and Brain Differences

Even though all people have the same basic brain makeup, there are structural, chemical, and functional differences in the male and female brains that result primarily from gender differences. This is not to say that all boy brains are identical and all girl brains are identical, but there are certain differences that can be tied to gender, and these differences have been corroborated worldwide (Gurian & Ballew, 2003; Jensen, 2008; Sousa, 2006).

Although the female brain is relatively smaller than the male brain, the size difference does not mean that one gender or the other has a functional advantage (Lenroot

et al., 2007). Brain development differs between the genders. Although both male and female brains develop at relatively the same rate, the difference comes in the parts of the brain that are developing as the child grows. The female brain develops quicker than the male brain in the areas that deal with language development, and the male brain develops more rapidly in the area of spatial sense.

The limbic system contains the hippocampus and the amygdala (Gurian et al., 2008; Sousa, 2006). Gender differences in the limbic system include the processing of emotions. Females process information and emotions at the same time. They can process and verbalize quickly because they are processing with all four lobes of the brain; however, females often have difficulty separating content from emotion and may become overwhelmed by emotional material. They tend to hold grudges for long periods. Females also tend to be better at reading emotional and non-verbal cues, which can result from differences in the limbic area. As a whole, they take in more sensory data because their senses are more acute (Gurian & Ballew, 2003). Males process emotive information through the bottom of the limbic system and brain stem, which may be the reason that males are more likely than females to act in an aggressive manner when emotions are in play. Gurian and Ballew (2003) noted that males also take more time to process emotional responses because less of males' brain activity during an emotional crisis involves the top of the brain where learning and verbal responses occur. Males can stay caught up in the emotion of the situation until enough time has passed to process what has occurred. This is an important piece of information to consider during instruction because while students are dealing with emotions no learning will occur.

A study of the amygdala by Cahill (2005) showed that males and females store emotional responses differently. Emotional responses are stored in the right amygdala for males, and these same responses are stored in the left amygdala for females. The right amygdala stores more of a holistic view of a situation, and the left amygdala stores a more detail-oriented memory. Translated to a classroom situation, this might mean that females will be more detail-oriented and naturally remember more specifics about a lesson or story, and male students might need to be trained to look for the detail.

The gender difference in the size of the hippocampus has been noted as a possible reason why males and females have different navigation preferences. Males are more likely to navigate by estimating distance and spatial orientation, and females are more likely to use landmarks (Cahill, 2005). This navigation difference between the genders is not unique to humans; scientists have also found the same gender navigation differences in the way that male and female rats navigate a maze.

The corpus callosum is the area of the brain that provides the neural connections that allow the left and right hemispheres of the brain to work together (Gurian & Ballew, 2003). The corpus callosum in females is much denser than in males, allowing females to more easily use both right and left hemispheres of the brain at the same time when processing information. Language development tends to be easier for females than males because the increased neural connectivity in the female brain allows for more interaction or cross talk between hemispheres providing for quicker verbal connections to the learning. Males tend to use one side of the brain when processing information (Sax, 2005). In the case of a brain defect, a female brain can many times compensate for the defect by using other parts of the brain. However, a male brain suffers more when a

defect is present because of the way the male brain compartmentalizes learning. When a male brain is damaged, there is no compensation for the damaged area; instead, the function that specific area of the brain performs is lost. This explains why males have greater difficulty recovering from a stroke. It might also provide an explanation for why more males are identified for special education services.

The cerebral cortex is the intellectual functioning area of the brain. Gurian et al. (2008) note that the female brain has more connections that are neural and a greater blood flow. Increased neural connections allow the female brain to process information and transition between activities quicker than the male brain. The average classroom experience is much easier for females than males because of greater interaction or cross talk between hemispheres of the brain.

Gurian et al. (2008) note that the cerebellum is larger in the male brain. This part of the brain is the action or doing center of the brain. The larger cerebellum and an increased amount of spinal fluid might account for the fact that some male students have trouble sitting still. This might also explain why some male students learn better when their bodies are in motion. Impulsive behavior is also found to be a part of the responses attributed to this area of the brain. A larger cerebellum might account for more male students being referred for Attention Deficit Hyperactivity Disorder (ADHD) behaviors.

There are differences between the genders and brain hemisphere preferences (Gurian et al., 2008). Use of the left hemisphere is more dominant in females, and males predominantly use the right hemisphere. The left hemisphere is known for structure and fact-based logical thinking. The right hemisphere allows for more abstract and holistic thinking. Most schools are structured to be more left-hemisphere friendly and therefore

are more conducive to the way the female brain works. The result is that females are more likely to enjoy school than males.

It is important to note again that all gender differences mentioned are generalizations and not indicative of all females or males. Gurian et al. (2008) labeled brains that function across the gender generalizations as "bridge brains." They note that according to brain scans performed at the Amen clinics in the United States and research by Baron-Cohen at Cambridge, one in five women and one in seven men are believed to fall in the bridge-brain category.

Brain-Based Learning

The goal of brain-based learning is to start with a focus on the learner and then the content (Jensen, 2008). The teacher sets up the conditions for learning to occur. Instead of looking at frameworks and content first, teachers using a brain-based approach to instruction work hard to know their students and how they best learn. Jensen lists the seven steps involved in planning for brain-based classrooms: pre-exposure, preparation, initiation and acquisition, elaboration, incubation and memory encoding, verification and confidence check, and finally, celebration and integration. This type of instructional planning is not linear because brains do not think in a linear manner.

Providing a single-sex environment allows teachers to focus on the varied but similar ways that students from the same gender learn.

Gurian et al. (2009) found the following:

> Teachers in coed classes who gain training in male-female brain differences report that both their boys and girls are learning and performing better. Teachers in single–sex classes generally find themselves better able to focus on the brain-

> gender spectrum for their specific students, giving both girls and boys more of the brain-friendly environment in which they can thrive. (p. 18)

Being able to concentrate on the needs of only one gender allows the teacher to focus the whole environment of the classroom toward the needs of that gender. While not all students of the same gender have exactly the same needs, in general a single-sex classroom environment can meet the generalized needs of the one gender.

Mathematics Achievement

Mathematics Achievement and Girls

A popular theory in American society states that girls on a whole do not have a propensity for mathematics. Support for this theory comes from a gender gap seen in mathematics tests such as the National Assessment of Educational Progress (NAEP) test (Institute of Educational Sciences, n.d.). However, a closer look at the NAEP test reveals that the differences between the genders in mathematics only form a gap of two points over the past decade (Geist & King, 2008). The Organisation for Economic Co-Operation and Development (OECD, 2009) notes that on the 2007 Trends in International Mathematics and Science Study (TIMSS), gender differences were not found at the fourth grade in overall mathematics performance. In eight of the 36 countries participating in the 2007 TIMSS study, girls scored significantly higher, and in 12 countries, boys scored significantly higher. On an average, however, no gender differences existed in overall mathematics performance. This finding was also seen in a study that looked at gender differences in mathematics on state assessments. Hyde et al., (2008) found no statistically significant difference between the scores of boys and girls

on mathematics tests across 10 states. They noted, however, that the state tests used were not rigorous enough to assess total math ability.

Several theories suggest reasons why girls might seem to lag behind boys in mathematics achievement. Geist and King (2008) referencing gender differences between NAEP tests given in 1978 and 1999 suggest that the high stakes testing and a back to the basics approach to teaching has benefited boys more than girls. In 1978, they noted that boys only scored higher than girls did in the 12^{th} grade. In 1999, boys scored higher in all levels. They also suggest that the way teachers interact with girls during the instructional process might demonstrate lower mathematics expectations for girls. A study conducted by Leedy, LaLonde, and Runk (2003) looked at attitudes of boys and girls participating in a regional math contest. Traditional gender-based attitudes that boys do better in math than girls existed even within the mathematically talented student population that was selected to attend this math competition. This study indicated a persistence of the belief that mathematics is a male domain. Gurian et al. (2009) suggest another possible issue contributing to the problem is that girls tend to lack confidence in their mathematics skills. They suggest that because girls attach more emotions to events, those emotions can create an opportunity for a lack of confidence when girls struggle with mathematics. Skelton and Francis (2003) note that girls tend to blame themselves for failure and attribute failure to a lack of ability. Boys, on the other hand, tend to blame failure on the teacher or the test.

In the early elementary years, the female brain is rapidly developing language skills located in the left hemisphere of the brain (Gurian & Ballew, 2003; Sax, 2005). However, the area of the brain that is used for mathematical reasoning develops more

slowly for girls. The strength of this development is seen in girls as they learn to read and write. Two areas of the female brain that work well together for girls are the memory and sensory areas. The use of real objects and manipulatives can be used to stimulate the sensory area and support girls during mathematical concept development (Gurian & Ballew, 2003).

Mathematics Achievement and Boys

The prevailing feeling is that boys excel in mathematics. One idea that might support the idea that boys do well in math is that at a young age, the male brain quickly develops in the area of spatial sense (Gurian et al., 2009; Sax, 2005). Manipulatives that boys can hold and move can be especially supportive when boys are learning mathematics. Although boys have been traditionally thought to be better at mathematics than girls are, some have questioned this idea as just a myth because the overall achievement gap between genders as seen on assessments such as the NAEP test is not that great.

Boys, however, do well in mathematics. Mead (2006) notes concerning the NAEP test scores from 1990 through 2005 that "boys of all ages and races are scoring as high – or higher – in math than ever before" (p. 3). The OECD (2001) notes that in mathematics literacy, boys did better on the 2000 Programme for International Student Assessment (PISA) test in half of the countries tested. On the 2003 PISA test that assessed mathematics skills, boys outscored girls overall (OECD, 2009).

Mathematics Achievement and Girls in Single-Sex Environments

Research is mixed concerning the effects of single-sex classrooms on girls' mathematics achievement. Laster (2004) found that girls participating in a single-sex

classroom environment show marginally higher achievement than girls do in a coeducational classroom environment. Laster's study involved sixth grade students from a Mississippi school, 33 girls and 33 boys participating in single-sex classes and a group of 33 coeducational students that included both boys and girls. The student lists were computer generated and included a diverse student population but did not include special education students. The same three teachers for math/social studies, science/computer, and English/reading taught both the single-sex and coeducation students. On the 2003 Mississippi state achievement test, 94% of the girls participating in the single-sex classes were proficient or advanced on the test compared to 92% of the girls in the coed classrooms.

In a study done in England, Spielhofer, O'Donnell, Benton, Schagen, and Schagen (2002) looked at data from 2,954 mixed and single-sex comprehensive and grammar schools including 369,341 students. Findings indicated that performance of girls in single-sex schools was slightly better for almost every attainment outcome when compared to girls in mixed school environments. Daly and Defty (2004) substantiated the findings of Spielhofer et al. (2002) in a study done in England that involved data collected on 42,000 students ages 15-16 years from 294 schools. They found that girls who participated in an all girls classroom had a modest mathematics achievement advantage and had more confidence in their mathematic abilities than girls who participated in coeducational classes. They did note, however, that the combination of classroom environment and higher mathematics achievement did not result in a causal relationship.

One of the strongest studies supporting single-sex classrooms was a three-year study done by Piechura-Couture, Tichenor, and Heins, (2007). The study looked at a variety of assessments for different grade levels. One of the assessments used was the Florida State Achievement Test (FCAT). Students begin taking the FCAT in the third grade. The study showed significant positive differences in overall achievement for students participating in single-sex classrooms based on the results of the FCAT. This study involved approximately 830 students in grades pre-kindergarten through fifth grade located at a public elementary school in central Florida. The demographics of this school included approximately 61% White, 25% Black, 13% Hispanic, and 1% Asian. Approximately 59% of the students qualified for free or reduced lunch. Teachers and students volunteered to participate in the single-sex classrooms. One section of single-sex classes (girls and boys) was offered for each grade level along with at least two coed classes. Because of these requirements, not all grades offered single-sex classrooms each of the three years. However, during the third year, single-sex classrooms were offered in all grades from kindergarten through fifth grade. In this study, only single-gender classroom achievement was found to have positive statistical significance. Within the single-sex girls' classes, the fourth grade single-sex girls' class showed the most significant positive results ($p = .009$) in mathematics achievement on the FCAT compared to the girls in coed classrooms. The fifth grade single-sex girls' class showed no difference in math scores between single-sex and coed classes ($p = .21$). The mathematics gains shown in both the fourth grade and fifth grade single-sex girls' classes were not significant ($p = .49$) and ($p = .51$), respectively. The death of a classmate 24 days prior to the assessment was identified as a contributing factor that caused lower

scores for the single-sex third grade girls' class (p = .51). No gains could be reported for third grade because this was the first time these students had taken the assessment.

Not all research is positive toward girls in single-sex classes and mathematics achievement. In a study of 600 sixth and seventh grade students in the Hudson Valley of New York State where participation in single-sex classes was voluntary, Spielhagen (2008) found that overall math scores on the state's Terra Nova test declined for girls participating in single-sex classes, and the scores for girls participating in coed classes increased. Spielhagen notes that the data were skewed by the fact that at the seventh grade level, only coeducational honors math classes were offered.

In a study of a first year implementation of single-sex classes in a fifth-grade at a public elementary school in central Mississippi, Gillis (2005) found no significant differences between girls in coeducational classrooms as opposed to single-sex classrooms. This study involved 73 fifth-grade students from a kindergarten through fifth grade school with a total student enrollment of 579. The participants included 69% White, 25% Black, and 6% of students with a variety of ethnic backgrounds. Twenty-five percent of the students were considered as living in poverty. It should be noted that all students in the fifth grade at this school were enrolled in single-sex classrooms. Coeducation at the fifth grade was not an option, and the assessment used was a pre and post assessment that was not well defined.

Hopkins (2001) substantiated these results by finding no significant differences in the mathematics scores of girls participating in coeducational classes compared to those in single-sex classes on the Flanagan mathematics test. This study took place in an inner-city school in Portsmouth, Virginia, a pre-kindergarten through fifth grade school with a

student population that is 99% Black and 99% poverty. One single-sex girls' class, one single-sex boys' class, and two coeducational classrooms at the second grade were the participants in the study. There were 20 boys and 22 girls enrolled in single-sex classes and 43 students enrolled in coed classes in the second grade.

Gibb, Fergusson, and Horwood (2008) conducted a longitudinal study of a birth cohort of 1,265 students that were born in 1977 in Christchurch, New Zealand. They noted a significant difference in girls' achievement levels that favored coeducational classroom environments over single-sex environments in both high school and tertiary education.

Mathematics Achievement and Boys in Single-Sex Environments

Research on mathematics achievement and boys participating in single-sex classrooms is mixed with many studies finding single-sex education providing no significant advantage for boys in the area of mathematics achievement. Background on the studies mentioned in this section can be found in the previous section. The three-year Piechura-Couture et al. (2007) Florida elementary school study found significance in FCAT math scores for fourth grade ($p = .02$) and fifth grade ($p = .04$) boys participating in single-sex classes. In looking at math gains scores on the FCAT, significance was found in the fourth grade ($p = .01$), but not in the fifth grade ($p = .59$).

The British Daly and Defty (2004) study, the Gibb et al. (2008) New Zealand study, and the Speilhagen (2008) study noted no mathematics achievement advantage for boys participating in a single-sex classroom. However, it was noted that in the Speilhagen study of sixth and seventh grade students, all honors math classes at the seventh grade were coeducation classes, which caused the data to be skewed in favor of coeducation

classes. Gillis' (2005) study of a Mississippi school in its initial implementation year of single-sex classes also found no statistically significant difference in mathematics mean scores on a pretest and posttest given to fifth grade boys participating in single-sex classrooms. This test, however, was not based on a standardized assessment. Hopkins (2001) administered the Flanagan math assessment as a pretest and posttest in his study with the pretest used as a covariant. Of the 85 second grade students participating in single-sex classes, Hopkins noted no significant difference in pretest and posttest scores for boys participating in single-sex classes.

Mathematics Achievement and Single-Sex Classrooms in General

Several studies looked at student achievement in single-sex classrooms in general without regard to sex. In a study of 4,128 sixth, seventh, and eighth grade students, Vrooman (2009) found a significant difference on mathematics achievement between students who participated in a single-sex class and students who participated in coeducational classes. The difference favored the students in the single-sex classroom environment. A 2008 U.S. Department of Education study of two single-sex academies located in the same district showed that mathematics students participating in the single-sex academies, with the exception of sixth grade girls, did not do as well as the district as a whole. In a 2005 U.S. Department of Education study of single-sex versus coeducation, 3 out of 14 studies that looked at mathematics achievement indicated advantages to single-sex education, 0 studies indicated advantages to coeducation, 8 studies indicated no difference, and 3 studies had mixed results. Spielhagen (2008) summed the research results by concluding that research supports the idea that single-sex classrooms work better for some students.

Literacy Achievement

Literacy Achievement and Girls

Early brain development favors girls in the area of language development (Gurian et al., 2009; Sax, 2005). The denser corpus collosum in a girl's brain allows both sides of a girl's brain to work together at the same time to make sense of text and language. Another advantage for girls is the fact that the majority of elementary teachers are women. Because of this, girls often relate to the types of books that their teachers enjoy, which creates a bond between teacher and student.

Recently, a growing reading achievement gap has been seen between genders on tests such as the National Assessment of Educational Progress (NAEP) test. Mead (2006) notes that girls outperform boys at all grade levels on the NAEP reading and writing tests. She states, "In general, girls outperform boys in reading and writing by greater margins than boys outperform girls in math, science and geography" (p. 6). The OECD (2001, 2009) notes that in reading literacy, girls did better on the 2000 PISA test in all countries. Three areas of reading are assessed on the PISA including retrieving information, interpretation, and reflection and evaluation. In each of these areas, girls scored higher than boys did. "On average, gender differences were 45 score points in favor of females on the reflection and evaluation scale, compared with 29 score points on the interpretation scale and 24 points on the retrieving information scale" (p.16). Mullis, Martin, Kennedy, and Foy (2007) found that fourth grade girls scored better on the 2006 Progress in International Reading Literacy Study (PIRLS) in all 40 countries and provinces tested. Literacy has shown to be an area where girls excel.

Literacy Achievement and Boys

Boys' literacy development is slower compared to girls. One of the issues confronting boys when they do not do well in literacy in the lower elementary levels of school is that they are referred for special education and/or behavior interventions at a young age (Benjamin, 2003; Garibaldi, 2006; Sax, 2005). Mead (2006) notes that two-thirds of students in special education are boys. Early identification for learning disabilities and behavior problems may be no more than the fact that boys mature slower in the area of language development and lose interest in reading at an early age. However, when a child is labeled as a special education student, the label becomes a way that the child begins to view himself. The child begins to believe that he has a problem and uses that belief to lower expectations for himself or give up completely. This creates boys who have given up on reading or lack confidence in their ability to read.

Younger and Warrington (2005) studied student achievement scores on England's National Curriculum tests from 2000 to 2004 and noted that boys were eight percentage points behind girls in the percentage of students scoring level two or above in reading. The gap widened in writing with boys scoring 11 percentage points behind girls in the number of students scoring at level two or higher. Girls also outperformed boys in literacy on the PIRLS, PISA, and the NAEP international assessments (Mead, 2006; Mullis et al., 2007; OECD, 2001).

OECD (2009) notes that there was an overall decline in reading scores between the PISA test given in 2000 and the PISA test given in 2006 and credits this decline to a statistically significant decrease in the performance of boys. One issue related to the underperformance of boys on reading assessments has to do with attitudes toward

reading. Boys were less interested in reading for pleasure, and boys noted that when they read, it was to gain information and not just because they want to read. A causal link was not identified, but enough information existed to suggest an association between reading attitudes and reading performance. "One standard deviation difference in the index of student interest is associated with a change of 27.9 score points on the PISA reading scale." (p. 17).

Literacy Achievement and Girls in Single-Sex Environments

Overall girls tend to excel in the area of literacy (OECD, 2001; OECD, 2009). Research studies however don't favor either coeducational or single-sex environments. Single-sex classrooms have not shown to have a significant difference in literacy achievement for girls (Piechura-Couture et al., 2007; U.S. Department of Education, 2008).

In the three-year study on a Florida elementary school enrolling students in kindergarten through fifth grade, Piechura-Couture et al. (2007) found significant results on FCAT scores in reading for fourth grade girls participating in a single-sex class (p = .04). The FCAT reading results of the fifth grade single-sex girls' class were not significant (p = .10). No significance was found in the reading gains scores of the either the fourth (p = .32) or fifth grade (p = .38) single-sex girls' classes.

Spielhagen (2008) in a study of 600 sixth and seventh grade students from a small urban school located in the Hudson Valley in New York noted gains in language arts on the Terra Nova test for girls participating in single-sex classes, and at the same time, losses were noted for girls enrolled in mixed classes. In the area of reading, both single-sex and coeducational girls made gains with coeducational girls making the greater gains.

A U.S. Department of Education (2008) study included data on two single-sex elementary schools (one male and one female) located in the same district. The study reported that 68.3% of third grade girls in the single-sex academy scored at or above the proficient level in reading compared to the district average of 66.4%. However, at the fourth grade level, only 35.7% of the girls in the single-sex academy scored at or above the proficient level in reading compared to the district average of 62.9%. Research shows mixed results in the area of literacy and girls in single-sex classrooms. Many studies show little difference in student achievement between single-sex classrooms and coeducational classrooms.

Literacy Achievement and Boys in Single-Sex Environments

Several studies have shown single-sex classrooms can make a difference for boys in the area of literacy achievement. Laster (2004) looking at data from the Mississippi Curriculum Test for grades two through eight found that the greatest differences for boys in single-sex classrooms and boys in coeducational classrooms were seen in the area of language arts. Boys participating in single-sex classrooms did significantly better than those in coeducational classrooms. Of the boys taught in single-sex classes, 88% were proficient or advanced on the Mississippi Curriculum test as compared to only 70% of the boys in the coed classes. In reading, 95% of the boys from single-sex classes were proficient or advanced compared to 85% of boys taught in coed classrooms.

In the three-year Florida elementary school study, Piechura-Couture et al. (2007) found significant results on FCAT scores in reading for fourth grade boys participating in a single-sex class ($p = .01$). Fifth grade FCAT reading scores for boys participating in a single-sex classroom were significant at the ($p = .04$) level. Significance was also seen in

the reading gains scores for boys participating in the single-sex boy classes at the fourth grade (p = .002), but not at the fifth grade (p = .09).

In a study in England sponsored by the National Foundation for Educational Research using the National value-added datasets (NVADs), Spielhofer, Benton, and Schagen (2004) noted that boys in single-sex grammar schools performed better than boys in mixed grammar schools did. The study suggests that boys in single-sex grammar schools achieve an average of 3.5 points higher on their General Certificates of Secondary Education (GCSE) as compared to boys in coed schools, included in this is a significant positive effect on the English point score. In most cases, the students that benefited most from single-sex education were students with lower ability levels. This study included data from 2,952 schools and 69,341 students.

Spielhagen's (2008) study of 600 sixth and seventh grade students noted that in the areas of reading and language arts, boys participating in single-sex classes showed the greatest gains on the Terra Nova test. The gains seen were greater than boys and girls in coed classes and girls in single-sex classes.

In a study from the University of Chicago that included about 11,600 students and 79 schools in Tennessee that looked at how class size effects student achievement, Whitmore (2005) indicated that boys might benefit from single-sex classes as they get past the second grade. Before the third grade, the study showed a benefit to boys when the class was coed and predominantly girls. The study suggested that a reason for this might be that before the third grade, the focus of reading is learning to read; at the third grade, however, the focus shifts to reading to learn. This focus shift might address some of the differences seen at the different grade levels.

Literacy Achievement and Single-Sex Classrooms in General

A section of the U.S. Department of Education (2008) study looked at the academic achievement of two single sex elementary academies, one for girls and one for boys located in the same district and compared by gender the achievement of these two schools to the achievement of the district as a whole mixing both genders. In the spring of 2003, the superintendent of this district made the decision to open the two single-sex academies without consulting those involved in the schools. These schools are described as being in the center of a city located in older buildings in African-American neighborhoods. Attendance in these schools was voluntary. After three years, the girls' academy was thriving, but the boys' academy was getting ready to welcome its fourth principal. In the fall of 2005, the all girl academy had 340 students, and the all boy academy had 150 students. The 2005 test data showed that 41.9% of third grade students in the all boys' academy scored at a proficient level in reading compared to 68.3% in the girls' academy and 66.4% overall in the district. In the boys' academy, 50% of fourth grade boys scored proficient in reading compared to 35.7% in the girls' academy and 62.9% overall in the district. Fifth grade reading showed 39.3% proficient in the boys academy, 53.3% in the girls' academy, and 59.5% overall in the district. In the sixth grade, only 12.9% of the students from the boys' academy were proficient in reading, with 89.4% proficient at the girls' academy and 60.6% proficient across the district.

Another part of the U.S. Department of Education (2008) study compared two dual academy elementary schools and one coed comparison school. These schools were located in urban communities in different states and served primarily African-American, at risk students. The percentage of students qualifying for free or reduced-price meals

ranged from 50% to 100% of the students. The dual academy schools had enrollments of 237 and 297. The coed school had an enrollment of 840 students. Looking at fourth grade reading test data, 50% of the students attending one of the dual academy schools were proficient on the state test with 79.5% of the students in that state being proficient (the other dual academy did not have data). The coed school had 29% of the fourth grade students proficient on the state test compared to 63% of students across that state proficient on the reading test.

In a study of 4,128 sixth, seventh, and eighth grade students in an urban school district, Vrooman (2009) found no significant differences in reading achievement between students that participated in single-sex classrooms and those participating in coeducational classrooms. The U.S. Department of Education (2005) study of single-sex versus coeducation looked at 10 studies that dealt with "Verbal/English Achievement Test Scores" (p. xiii) finding that 3 of the studies favored single-sex education, 0 favored coeducation, and 7 reflected neutral results. Spielhagen (2008) noted that single-sex classrooms appear to work best for younger students.

Stanford Achievement Test

Across the United States, there are three standardized tests used to assess student achievement. NCS Pearson's Stanford Achievement Test (SAT), and CTB/McGraw Hill's TerraNova Test each has 40% of the market; Riverside Publishing's Iowa Test of Basic Skills (ITBS) has the remaining 20% of the market. Each of these tests is a norm-referenced test that measures a student's performance against other students taking the same test. The SAT version 10 (SAT-10) is what the state of Arkansas is currently using as part of the No Child Left Behind (NCLB) testing.

SAT-10 reliability was assessed through internal-consistency measures and alternate-form measures (Pearson Education, 2004; SEDL, 2010). The SAT version 9, Otis-Lennon assessments and bias committees were used to support the validity of the SAT-10 assessment. One of the reliability measures used by NCS Pearson was the Kuder-Richardson Formula 20 (KR_{20}) (Pearson Education, 2004). The KR_{20} reliability coefficient results for each of the assessments being used in this study are as follows: second grade reading comprehension (.91), second grade math problem solving (.89), third grade reading comprehension (.92), third grade math problem solving (.91), fourth grade reading comprehension (.93), and fourth grade math problem solving (.92).

Pearson Education (2004) notes that when looking at data over time or at different testing levels, it is not appropriate to use raw scores. SAT-10 raw scores are converted to scaled scores allowing one level of the test to be compared to another. The SAT-10 assessment was standardized with a nation-wide representative sample of students during the spring and fall of 2002. A stratified cluster sampling was done using classrooms as the clusters. The sample was stratified by region, socioeconomic status, urban city, and ethnicity. All students in each class were involved in the testing sample except those students classified as Severely/Profoundly Mentally Disabled or those that could not be tested under the specified standardized testing conditions.

In Arkansas, second grade students only take the reading comprehension and math problem solving portions of the SAT-10. The reading comprehension test assesses a students' ability to comprehend what they read within literary, informational, and functional texts. The mathematics portion of the SAT-10 spans the content recommended by the National Council Teachers of Mathematics. Third and fourth grade students take

the reading comprehension and math problem solving sections of the SAT-10 as part of an augmented benchmark test. The augmented test combines the norm-referenced SAT-10 with a criterion-referenced test based on the Arkansas student performance standards.

Conclusion

Since the implementation of NCLB and Title IX revisions allowing public schools to offer single-sex classrooms, there has been a growing response within public schools to see if single-sex classrooms might be a better way to support the learning needs of students (National Association for Single-Sex Public Education, n.d.a). Using brain-based research, teachers can design classrooms and instruction focused on supporting gender differences and needs (Gurian et al., 2009). The goal is to increase student learning and student achievement.

"Educators are in the only profession whose job is to change the human brain every day" (Sousa, 2006, p. 10). The more teachers know about how the brain works, the more success they will have with helping students learn. Using brain-imaging technology, brain research has identified structural and processing differences between male and female brains. Teachers can use this information to meet the needs of individuals and groups of students in their classrooms. The achievement differences between genders might be connected to differences in how male and female brains process information in learning and how schools and classroom instruction are structured (Sax, 2005). Teachers do not always consider male and female differences when preparing for classroom instruction, but when brain research concerning gender differences is used to drive classroom instruction, positive results can occur (Jensen, 2008). Jensen states "In fact, of all the reforms, nothing provides a better return on your

investment of time, energy and money than developing a brain-based approach to learning" (p. xiii).

Although popular opinion suggests that males tend to perform better in mathematics and females tend to perform better in literacy, the review of literature shows that the only significant achievement gap between genders occurs in the area of literacy. Males tend to fall behind females significantly on literacy assessments. The OECD (2009) raises the concern that this gender gap is not remaining constant over the years but instead is growing more pronounced. Although boys tend to score better than girls do in mathematics, the gender gap is not as great as the gap seen in the area of literacy.

Salmone (2003) states that research comparing the benefits of single-sex classrooms to coeducational classrooms has to date not given any definite answers. The problem is not necessarily the two types of classrooms as it is the ability to exert control over research designs to provide cause and effect relationships. Given the legal parameters surrounding single-sex education, it is difficult to utilize random selection or assignment for the research participants for a study. It is also difficult to control for extraneous factors that might create differences such as a variety of instructors, instructional styles, student backgrounds, and school cultures. Although the research has yielded mixed results, single-sex classrooms have not been shown to harm students academically. Overall, single-sex classes have been shown to work for some students as an intervention to increase student achievement, but the single-sex class format does not work for all students or in every situation. Teacher training has been noted as a key to successful single-sex classroom implementation.

Because single-sex education in the public school setting is a relatively new phenomenon, there is not enough research yet to know if this intervention should be supported. Much of the current research has been done in secondary schools and overseas. More research needs to be documented at the elementary levels (U.S. Department of Education, 2005; American Institutes for Research, 2004). Research also suggests that further studies need to be done to look at how single-sex classroom instruction might affect student achievement with regard to socioeconomic status and race (Cable & Spradlin, 2008).

This research project was designed to add to the limited available research concerning the effectiveness of single-sex education within a public elementary school setting. Following the first year of implementation of a single-sex classroom pilot program, the effects by gender of classroom grouping (single-sex education versus coeducation) on reading and math achievement were investigated for three consecutive grade levels from second grade through fourth grade. As suggested by the research, single-sex classroom teachers in this pilot program were provided with training and support to increase the opportunity for successful implementation (Gurian et al., 2009; National Association for Public Single-Sex Education, n.d.a).

CHAPTER III

METHODOLOGY

A 2005 United States Department of Education review of single-sex education research found that there were few rigorous research studies on the topic of single-sex education. The current research shows that single-sex classrooms work for some students, but not for all students (Spielhagen, 2008). The concept of single-sex classrooms as an alternative education option for public school students is a recent phenomenon, and the review of literature encourages more research in this area. Several areas for further single-sex education research have been identified. Two of the identified areas include research in elementary schools and the need for more quantitative research methods. This research project addresses both of these two identified weaknesses.

This study examined the effects of single-sex education on literacy and math student achievement by gender for students in the second, third, and fourth grades in a rural Northwest Arkansas school district. The research hypotheses are as follows:

1. No significant difference will exist by gender between second grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement.
2. No significant difference will exist by gender between second grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement.

3. No significant difference will exist by gender between third grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement.
4. No significant difference will exist by gender between third grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement.
5. No significant difference will exist by gender between fourth grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement.
6. No significant difference will exist by gender between fourth grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement.

This chapter will discuss the research design, the process of obtaining a sample, and a description of the sample population. The instrument used to measure student achievement will be discussed and the data collection and statistical analysis processes will be detailed. Finally, the limitations of the study will be analyzed.

Research Design

A causal-comparative study was conducted in a rural school district in Northwest Arkansas. In the spring of 2009, 12 teachers volunteered to pilot single-sex classes in second, third, and fourth grades. The district's curriculum director and principals of the two schools received approval from the local school board to offer two all boy and two all girl classes at the second, third, and fourth grade levels. A posttest was used to compare math student achievement between students participating in single-sex

classrooms to students participating in coeducational classrooms by gender for three different grade levels. In addition, a posttest was also used to look at literacy achievement between students participating in single-sex classrooms to students participating in coeducational classrooms by gender for three different grade levels. According to Gay, Mills, and Airasian (2009), a causal-comparative study was appropriate in this situation because the effects and causes were being studied after the fact.

Sample

The study was conducted in a rural Northwest Arkansas School District with a student enrollment of about 3,800 students in grades kindergarten through twelfth grade. Schools in this district are grade level specific with separate schools for the following grade level configurations: pre-kindergarten-kindergarten, 1-2, 3-5, 6-8, and 9-12. The district reports 16 different home languages with 81% of the students claiming English as their home language and 18% claiming Spanish as their home language. Approximately 65% of the student population is white, 25% Hispanic, 6% Native American, 3% Asian, 1% Black, and less than 1% Hawaiian/Pacific Islander. Based on the district's free and reduced lunch count, approximately 55% of the students across the district come from poverty.

In the fall of 2009, teachers from two different elementary schools asked permission from the administration to pilot single-sex classes in second, third, and fourth grades. In May of 2009, the district's curriculum director and principals of the two schools involved in the study received the approval from the local school board to offer two all boy and two all girl classes at three different grade levels: second, third, and fourth for the 2009-2010 school year. After an informational parent meeting to explain

the possible benefits of single-sex classrooms, parents and students were offered the choice of participating in single-sex classrooms or coeducational classrooms. After all the students requesting single-sex classrooms were placed, principals filled the classes by trying to match the demographics of the school and by including students with a variety of intellectual levels. Principals contacted the parents of those students selected to fill the classes to get permission to place these students in the single-sex classrooms. At the beginning of the 2009-2010 school year, second, third, and fourth grades had two all girl classes and two all boy classes. There were also nine coeducational classes in the second grade, nine coeducational classes in the third grade, and eight coeducational classes in the fourth grade.

Students Eliminated from the Study

Students who did not complete both the reading and math portions of the SAT-10 during both the 2009 and 2010 school years were eliminated from the study. Students not completing the testing included a few special education students and a few Limited English Proficient (LEP) students who were exempted from testing. To ensure that the students were enrolled in the respective classes for the majority of the school year, students who enrolled after October 1, 2009 were also eliminated. The October 1 date was selected because this was the date used by the Arkansas Department of Education in determining which student achievement scores the district would be held accountable for under No Child Left Behind. Students enrolled after October 1 were considered "highly mobile" students, and their scores did not count for or against the school when calculating adequate yearly progress (Arkansas Department of Education, 2009).

Matched Pairs

After eliminating students who did not complete the SAT-10 testing during both the 2009 and 2010 school years and those enrolled after October 1, 2009, students in the single-sex classrooms were matched with students in the coeducational classrooms. The United States Department of Education (2003) described factors to be included in a comparison-group study that might produce "possible" evidence of a successful intervention. One of the factors included closely matching the intervention and comparison groups by prior test scores, demographic characteristics, time period studied, and methods used to collect outcome data. In this study, single-sex classroom students were matched to coeducational students by grade, gender, socioeconomic status, 2009 literacy proficiency level, and 2009 math proficiency level. The Arkansas Department of Education based their four proficiency levels on the SAT-10 scores for the second and third grade students in the study and on the Arkansas Augmented Benchmark Exam for the fourth grade students. The Arkansas Augmented Benchmark Exam includes the norm-referenced SAT-10 combined with a criterion-referenced exam developed for Arkansas (Arkansas Department of Education, 2009). The four proficiency levels categorize students as below basic, basic, proficient, or advanced. Matching by socio-economic status and these four proficiency levels in both literacy and math created 32 different categories for each gender and each grade of students. An example of a match would be a single-sex classroom student considered to be in poverty that performed at the basic level in literacy and performed at the advanced level in math. This student would be matched to a coeducational classroom student of the same gender and grade level

considered to be in poverty that performed at the basic level in literacy and performed at the advanced level in math.

All second grade classrooms were self-contained classrooms. In the second grade, there were approximately 300 students; of the 300 students, 47 boys and 46 girls were enrolled in single-sex classrooms. Exact matches were made for 28 boys and 33 girls. Difficulty in matching came from the fact that not all LEP students tested as first graders making it impossible to match them by the previous year's proficiency scores. Table 1 shows the demographic breakdown for the students in the second grade sample.

Table 1

Demographics for Second Grade Students

	Girls		Boys	
	SS (n = 33)	Coed (n = 33)	SS (n = 28)	Coed (n = 28)
White	23	24	22	21
Hispanic	5	3	4	5
Other	5	6	2	2

Note. SS = single-sex classes, Coed = coeducational classes. The category *Other* includes students identified as Black, Asian, Indian, and Pacific/Islander.

Table 2 shows the curriculum breakdown for students in the second grade sample. Approximately 33% of the girls and 29% of the boys in the second grade sample came from a low socio-economic status. In the second grade as a whole, 64% of the students came from a low socio-economic status. The sample also included six LEP girls, four from the treatment group and two from the control group. There were no LEP boys included in the sample.

Table 2

Curriculum Breakdown for Second Grade Students

	Girls		Boys	
	SS (n = 33)	Coed (n = 33)	SS (n = 28)	Coed (n = 28)
Regular	30	32	21	22
GT	1	0	6	6
SPED	2	1	1	0

Note. SS = single-sex classes, Coed = coeducational classes, Regular = students assigned to a general curriculum, GT = students assigned to a gifted and talented curriculum, SPED = students assigned to a special education curriculum.

Third grade classroom teachers work in pairs where one teacher teaches English and social studies for both classes and the partner teacher teaches math and science for both classes. In the third grade, there were approximately 310 students; of the 310 students, 46 boys and 47 girls were enrolled in single-sex classrooms. Exact matches were made for 33 boys and 35 girls. Table 3 shows the demographic breakdown for the students in the third grade sample.

Table 3

Demographics for Third Grade Students

	Girls		Boys	
	SS (n = 35)	Coed (n = 35)	SS (n = 33)	Coed (n = 33)
White	26	28	22	23
Hispanic	5	2	7	8
Other	4	5	4	2

Note. SS = single-sex classes, Coed = coeducational classes. The category other includes students identified as Black, Asian, Indian, and Pacific/Islander.

Table 4 shows the curriculum breakdown for students in the third grade sample. Approximately 37% of the girls and 39% of the boys in the third grade sample came from a low socio-economic status. In the third grade as a whole, 55% of the students came from a low socio-economic status. The sample also included seven LEP girls, four from the treatment group and three from the control group. There were 12 LEP boys included in the sample, four from the treatment group and eight from the control group.

Table 4

Curriculum Breakdown for Third Grade Students

	Girls		Boys	
	SS (n = 35)	Coed (n = 35)	SS (n = 33)	Coed (n = 33)
Regular	31	30	30	31
GT	4	3	1	1
SPED	0	2	2	1

Note. SS = single-sex classes, Coed = coeducational classes, Regular = students assigned to a general curriculum, GT = students assigned to a gifted and talented curriculum, SPED = students assigned to a special education curriculum.

Fourth grade classroom teachers work in pairs where one teacher teaches English and social studies for both classes while the partner teacher teaches math and science for both classes. In the fourth grade, there were approximately 295 students; of the 295 students, 47 boys and 50 girls were enrolled in single-sex classrooms. Exact matches were made for 40 boys and 42 girls. Table 5 shows the demographic breakdown for the students in the fourth grade sample.

Table 5

Demographics for Fourth Grade Students

	Girls		Boys	
	SS (n = 42)	Coed (n = 42)	SS (n = 40)	Coed (n = 40)
White	24	30	27	30
Hispanic	14	12	13	8
Other	4	0	0	2

Note. SS = single-sex classes, Coed = coeducational classes. The category other includes students identified as Black, Asian, Indian, and Pacific/Islander.

Table 6 shows the curriculum breakdown for students in the fourth grade sample. Approximately 52% of the girls and 65% of the boys in the fourth grade sample came from a low socio-economic status. In the fourth grade as a whole, 61% of the students came from a low socio-economic status. The sample also included 23 LEP girls, 13 from the treatment group and 10 from the control group. There were 18 LEP boys included in the sample, 11 from the treatment group and 7 from the control group.

Table 6

Curriculum Breakdown for Fourth Grade Students

	Girls		Boys	
	SS (n = 42)	Coed (n = 42)	SS (n = 40)	Coed (n = 40)
Regular	33	38	37	29
GT	4	3	2	4
SPED	5	1	1	7

Note. SS = single-sex classes, Coed = coeducational classes, Regular = students assigned to a general curriculum, GT = students assigned to a gifted and talented curriculum, SPED = students assigned to a special education curriculum.

Instrumentation

The instrument used to measure student achievement was the Stanford Achievement Test Version 10 (SAT-10). The SAT-10 is a product of Pearson Education, Inc. The SAT-10 is the norm-referenced assessment used by the Arkansas Department of Education as part of No Child Left Behind (Arkansas Department of Education, 2008). Pearson Education was given the Arkansas student assessment contract in 2007 because they were willing to create an augmented test for third grade through eighth grade that would use norm-referenced test items from the SAT-10 that could also be used as criterion-referenced test items to assess mastery of the Arkansas student learner expectations. Pearson also agreed to meet the timeline set forth by the Arkansas Department of Education for the receipt of test results and agreed to release 50% of the pure criterion-referenced test items each year. In Arkansas, first, second, and ninth grades administer the SAT-10 strictly as a norm-referenced test, but in the third through eighth

grades, the SAT-10 is given as part of the Arkansas Department of Education Augmented Benchmark Exam.

In Arkansas, second grade students only take the reading comprehension and math problem solving portions of the SAT-10 (Arkansas Department of Education, 2008). The reading comprehension test assesses a student's ability to comprehend what they read within literary, informational, and functional texts (Arkansas Department of Education, 2009). Students read each selection and then answer a series of multiple-choice questions pertaining to the selection. The mathematics problem-solving subtest measures a student's ability to solve problems within the National Council of Teachers of Mathematics categories of number sense and operations, algebra, geometry, measurement, data analysis and probability. All SAT-10 items are in a multiple-choice format. The items contain both knowledge level questions as well as questions that require students to use problem-solving processes (Pearson Education, 2004). The reading comprehension test contains 40 items at the second grade and 54 items at both the third and fourth grades. The mathematics problem-solving test contains 44 items at the second grade, 46 items in third grade, and 48 items in the fourth grade. Third and fourth grade students take the reading comprehension and math problem solving sections of the SAT-10 as part of the Arkansas Augmented Benchmark Exam. The augmented test combines the norm-referenced SAT-10 with a criterion-referenced test based on the Arkansas student performance standards.

The SAT-10 assessment was standardized with a nation-wide representative sample of students during the spring and fall of 2002. A stratified cluster sampling was done using classrooms as the clusters. The sample was stratified by region,

socioeconomic status, urban city, and ethnicity. All students in each class were involved in the testing sample except those students classified as Severely/Profoundly Mentally Disabled or those that could not be tested under the specified standardized testing conditions.

Pearson Education (2004) notes that when looking at data over time or at different testing levels, it is not appropriate to use raw scores. SAT-10 raw scores are converted to scaled scores allowing one level of the test to be compared to another from kindergarten through the twelfth grade. The reading comprehension and math problem solving scores used in this study were scaled scores taken from the SAT-10, which was administered in April 2010. The SAT-10 was administered in a standardized manner to all first through ninth grade students across the state of Arkansas. The Arkansas Department of Education provides test administration training for district and school test coordinators. The local district coordinators then train the teachers who will be administering the test. Only licensed teachers who have been trained in testing procedures may administer the SAT-10 and Arkansas Augmented Benchmark Exams.

SAT-10 reliability was assessed through internal-consistency measures and alternate-form measures (Pearson Education, 2004; SEDL, 2010). The SAT version 9, Otis-Lennon assessments, and bias committees were used to support the validity of the SAT-10 assessment. One of the reliability measures used by NCS Pearson was the Kuder-Richardson Formula 20 (KR_{20}) (Pearson Education, 2004). The KR_{20} reliability coefficient results for each of the assessments being used in this study are as follows: second grade reading comprehension (.91), second grade math problem solving (.89), third grade reading comprehension (.92), third grade math problem solving (.91), fourth

grade reading comprehension (.93), and fourth grade math problem solving (.92). These coefficients indicate a strong internal consistency.

Data Collection Procedures

Following IRB approval on February 2, 2010 (see Appendix M), the local district assigned each student in second, third and fourth grades with an eight-digit code to secure the identity of the students. The first two digits identified the school, the third identified the grade, the fourth identified the group designation, the fifth identified the gender, and the last three digits were randomly assigned. The researcher collected current student demographic data from the student registration information, the 2009 student literacy proficiency levels, and the 2009 student math proficiency levels. The week following the April, 2010 SAT-10 testing window, the researcher received a list of students that did not complete the 2010 SAT-10 testing. These data were necessary to identify matched pairs of single-sex and coeducational students and were received from the Assessment and Accountability Director of the District. Excel software was used to sort students and create groups to identify matches. Only students who completed both the 2009 and 2010 SAT-10 assessments were included in the population from which the matched samples were drawn. Matches were completed in May prior to the return of the 2010 test results. The district provided a person to hand code the SAT-10 2010 scaled scores for each student identified in the study before the data was released to the researcher in June 2010. The data was hand coded because the district was not able to get digital Excel files of the test results until the end of the summer. Then, the test data were entered into Excel spreadsheets by the researcher. Data were stored on two USB drives. The drives were kept locked in a fireproof safe when not being used by the researcher.

Analytical Methods

To address the first, third, and fifth hypotheses, three 2 x 2 factorial analysis of variances (ANOVAs) were conducted using classroom type (single-sex versus coeducational) by gender (male versus female) as independent variables and math achievement as the dependent variable for the three different grade levels: second, third, and fourth, respectively. To address the second, fourth, and sixth hypotheses, three 2 x 2 factorial ANOVAs were conducted using classroom type (single-sex versus coeducational) by gender (male versus female) as independent variables and literacy achievement as the dependent variable for the three different grade levels: second, third, and fourth, respectively. The factorial ANOVA was selected in order to examine the main effects of gender and classroom placement as well as to examine the interaction effects between gender and classroom placement. To test the null hypotheses, the researcher used a two-tailed test with a .05 level of significance.

Limitations

It is important to note any limitations that might have an adverse effect on the results of this study. This allows the reader to determine what if any effect these conditions might have had upon the interpretation of the results. The following were limitations associated with this study.

The first limitation was that several LEP students, especially those enrolled in the second grade, were exempt from testing during the previous 2009 school year because of their limited English skills. This limited the number of students, especially in the second grade single-sex boys' classes, that could be used for the matching process. Because of this, only 28 matches were made for second grade boys.

Another limitation was that the researcher had to rely on the district to make sure that the assigned numbers given to students before the matching process were correctly associated with the same students when the evaluation assessment data was received. The data was hand coded because digital data was not available. Although great care was taken in this process and the data was checked for accuracy, there is always the possibility of human error.

A third limitation was that the participants in the single-sex classes volunteered to participate in this pilot program. At times, self-selection for treatment increases the possibility of the Hawthorn Effect because participants might perform better just because they know that they are being monitored (Ravid, 2005).

A fourth limitation to consider was that the teachers in the single-sex classrooms also volunteered to participate in this pilot program. These teachers were motivated to make this pilot program successful. Because of their original interest in the program, the possibility of the Hawthorn Effect was increased by the fact that they wanted the program to be successful (Ravid, 2005).

CHAPTER IV

RESULTS

This research took a quantitative approach to examine the effects of single-sex education on literacy and math student achievement by gender for students in the second, third, and fourth grades in a rural Northwest Arkansas school district. The independent variables were gender (male/female) and classroom placement (single-sex/coeducational). The dependent variables were math and literacy scale scores from the Stanford Achievement Test Version 10 (SAT-10). Factorial Analysis of Variance (ANOVAs) were run to look at each of the six research hypotheses. Due to multiple statistical tests being run, a Bonferonni adjustment was used to modify the alpha level from .05 to .025 to correct for alpha inflation because each of the samples was tested twice. The stricter alpha level will help control for Type 1 errors (Pallant, 2007). The results of this analysis are found in this chapter.

Hypothesis 1

Hypothesis 1 stated that no significant difference will exist by gender between second grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement. The population from which the sample was taken was normally distributed. No outliers were found within the sample groups (see Appendix A for a comparison of the group distributions).

Data for sample groups were normally distributed. Group means and standard deviations are displayed in Figure 1.

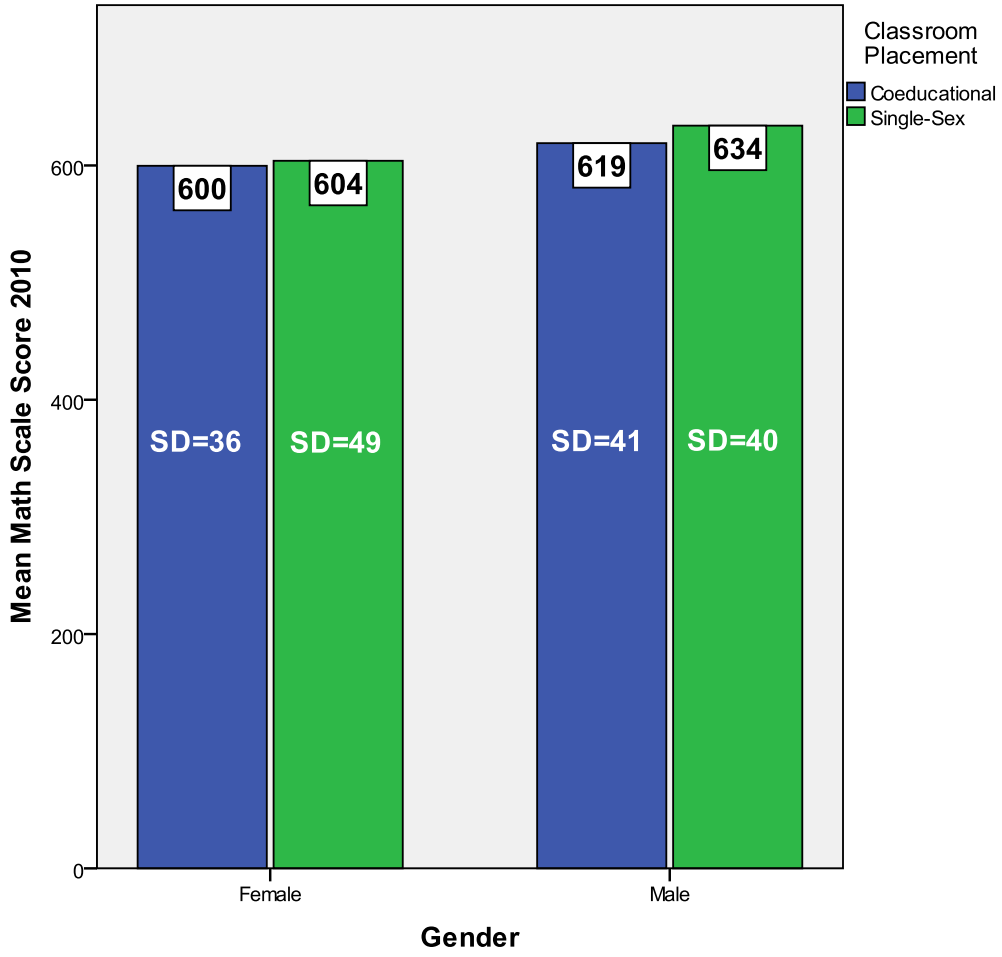

Figure 1. Second grade math problem solving means and standard deviations.

Levene's test of equality of variances was conducted within ANOVA and indicated homogeneity of variance across groups $F(3, 118) = 1.37$, $p = .26$. A line plot of gender and classroom placement indicated no interaction between factors (see Appendix B).

A Univariate ANOVA was conducted to explore the impact of gender (male, female) and classroom placement (coeducational, single-sex) on math achievement as

measured by the math problem solving scaled scores from the Stanford Achievement Test Version 10 (SAT-10). The results of the ANOVA are displayed in Table 7.

Table 7

Second Grade Math ANOVA Results

Source	*SS*	*df*	*MS*	*F*	*P*	*ES*
Gender*Classroom	859.98	1	859.98	.49	.487	.004
Gender	18432.87	1	18432.87	10.44**	.002	.081
Classroom	2792.37	1	2792.37	1.58	.211	.013
Error	208403.87	118	1766.13			

Note: ** The mean difference is significant at the .01 level.

The interaction effect between gender and classroom placement was not statistically significant, F (1, 118) = .49, p = .49. There was a statistically significant main effect for gender, F (1, 118) = 10.44, $p < .01$, with a small partial eta squared effect size equal to .08. The main effect for classroom placement F (1, 118) = 1.59, p = .21, did not reach statistical significance.

Hypothesis 2

No significant difference will exist by gender between second grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement. The population from which the sample was taken was normally distributed. No outliers were found within the sample groups (see Appendix C for a comparison of the group distributions).

Data for sample groups were normally distributed. Group means and standard deviations are displayed in Figure 2.

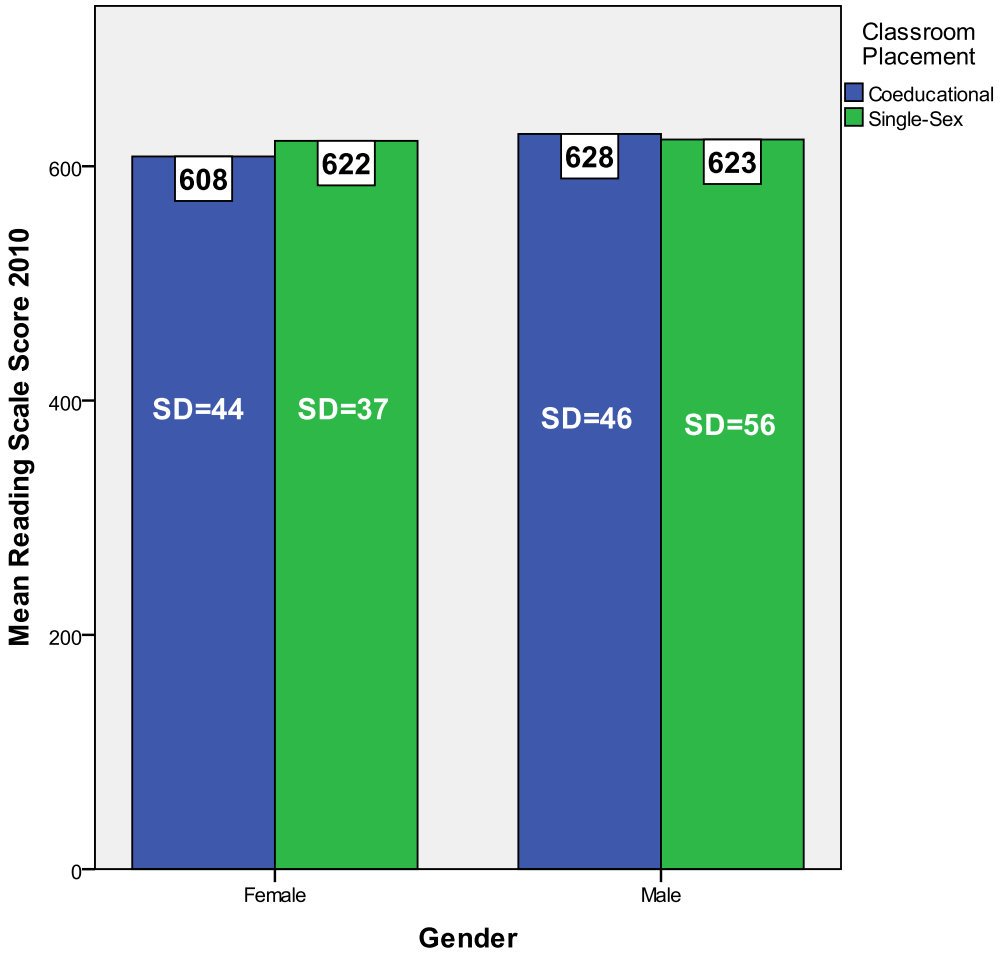

Figure 2. Second grade reading comprehension means and standard deviations.

Levene's test of equality of variances was conducted within ANOVA and indicated homogeneity of variance across groups $F(3, 118) = 1.51$, $p = .22$. A line plot of gender and classroom placement indicated interaction between factors (see Appendix D).

A Univariate ANOVA was conducted to explore the impact of gender (male, female) and classroom placement (coeducational, single-sex) on reading achievement as measured by the reading comprehension scaled scores from the Stanford Achievement Test Version 10 (SAT-10). The results of the ANOVA are displayed in Table 8.

Table 8

Second Grade Reading ANOVA Results

Source	*SS*	*df*	*MS*	*F*	*P*	*ES*
Gender*Classroom	2468.38	1	2468.38	1.180	.279	.010
Gender	3140.34	1	3140.34	1.500	.223	.013
Classroom	554.05	1	554.05	.265	.608	.002
Error	246681.93	118	290.53			

While the line plot indicated interaction between the factors gender and classroom placement, the interaction was not statistically significant, F (1, 118) = 1.18, p = .28. The main effect for gender F (1, 118) = 1.50, p = .22, did not reach statistical significance. The main effect for classroom placement F (1, 118) = .27, p = .61 was also not statistically significant to the differences seen between the means.

Hypothesis 3

No significant difference will exist by gender between third grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement. The population from which the sample was taken was normally distributed. Five outliers were found within the sample groups. Outliers were recoded to the nearest score within the acceptable range (Mertler & Vannatta, 2005) (see Appendix E for a comparison of the group distributions).

Data for sample groups were normally distributed. Group means and standard deviations are displayed in Figure 3.

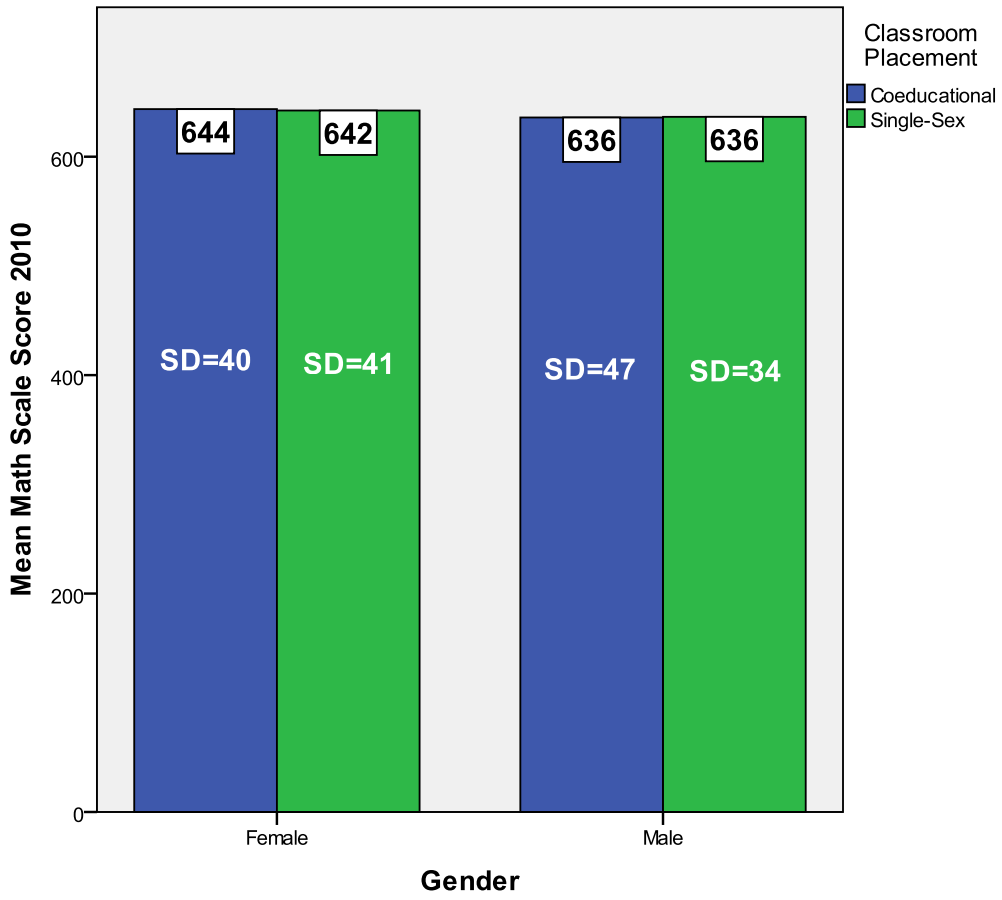

Figure 3. Third grade math problem solving means and standard deviations.

Levene's test of equality of variances was conducted within ANOVA and indicated homogeneity of variance across groups $F(3, 132) = .65$, $p = .59$. A line plot of gender and classroom placement indicated interaction between factors (see Appendix F).

A Univariate ANOVA was conducted to explore the impact of gender (male, female) and classroom placement (coeducational, single-sex) on math achievement as measured by the math problem solving scaled scores from the Stanford Achievement Test Version 10 (SAT-10). The results of the ANOVA are displayed in Table 9.

Table 9

Third Grade Math ANOVA Results

Source	*SS*	*df*	*MS*	*F*	*P*	*ES*
Gender*Classroom	29.43	1	29.43	.02	.895	.000
Gender	1539.36	1	1539.36	.92	.341	.007
Classroom	4.28	1	4.28	.003	.960	.000
Error	222088.68	132	1682.49			

While the line plot indicated an interaction between the factors gender and classroom placement, the interaction effect was not statistically significant, F (1, 132) = .06, p = .80. The main effect for gender, F (1, 132) = .61, p = .44, did not reach statistical significance. The main effect for classroom placement F (1, 132) = .08, p = .77, also did not reach statistical significance.

Hypothesis 4

No significant difference will exist by gender between third grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement. The population from which the sample was taken was normally distributed. Four outliers were found within the sample groups. Outliers were recoded to the nearest score within the acceptable range (Merler & Vannetta, 2005) (see Appendix G for a comparison of the group distributions).

The Kolmogorov-Smirnov test for the coed girls' group yielded a significant result KS = .007, indicating a non-normal distribution. However, data for the other three sample groups were normally distributed and analysis of variance is robust to violations

of the normality assumption (Mertler & Vannatta, 2005). Group means and standard deviations are displayed in Figure 4.

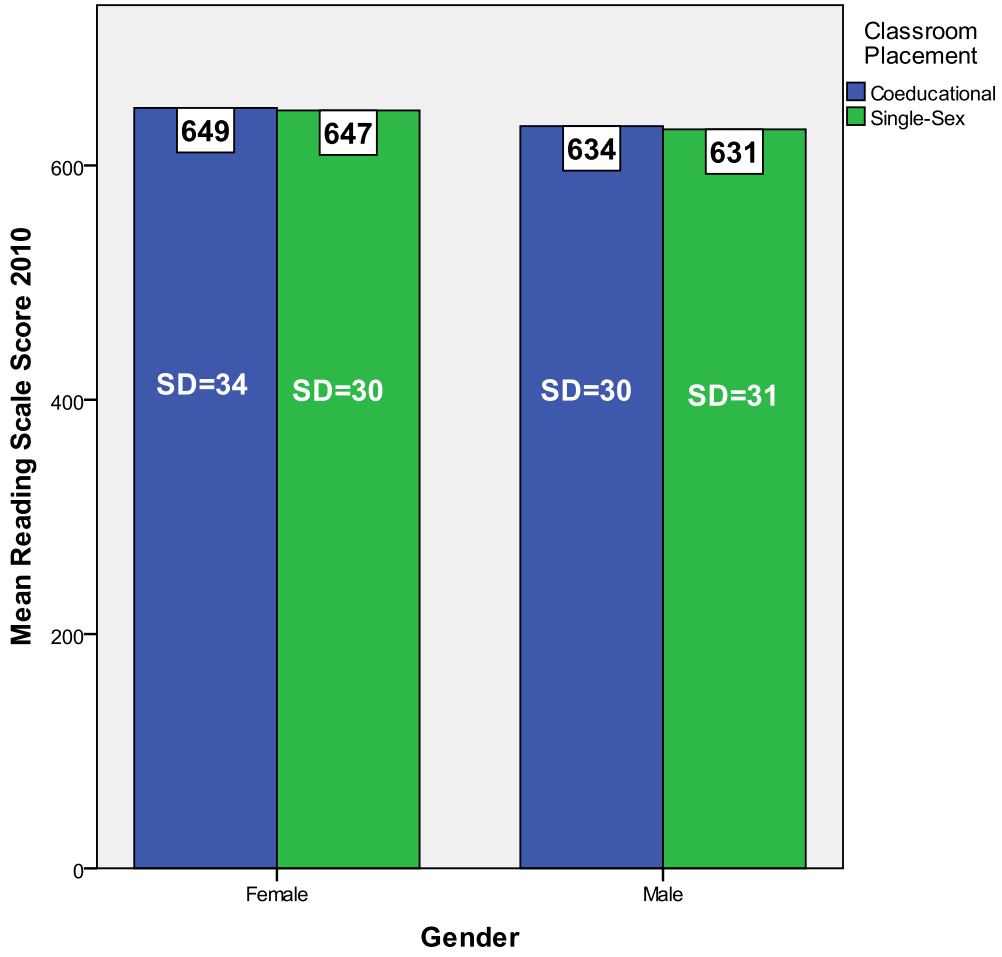

Figure 4. Third grade reading comprehension means and standard deviations.

Levene's test of equality of variances was conducted within ANOVA and indicated homogeneity of variance across groups F (3, 132) = .12, p = .95. A line plot of gender and classroom placement indicated no interaction between factors (see Appendix H).

A Univariate ANOVA was conducted to explore the impact of gender (male, female) and classroom placement (coeducational, single-sex) on reading achievement as

measured by the reading comprehension scaled scores from the Stanford Achievement Test Version 10 (SAT-10). The results of the ANOVA are displayed in Table 10.

Table 10

Third Grade Reading ANOVA Results

Source	*SS*	*df*	*MS*	*F*	*P*	*ES*
Gender*Classroom	3.19	1	3.19	.003	.955	.000
Gender	8530.68	1	8530.68	8.550**	.004	.061
Classroom	199.07	1	199.07	.200	.656	.002
Error	131746.81	132	998.08			

Note: ** The mean difference is significant at the .01 level.

The interaction effect between gender and classroom placement was not statistically significant, F (1, 132) < .00, p = .96. The main effect for gender was statistically significant, F (1, 132) = 8.55, p < .01, with a small partial eta squared effect size equal to .06. The main effect for classroom placement, F (1, 132) = .20, p = .66, did not reach statistical significance.

Hypothesis 5

No significant difference will exist by gender between fourth grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement. The population from which the sample was taken was normally distributed. Two outliers were found within the sample groups. Outliers were recoded to the nearest score within the acceptable range (Mertler & Vannatta, 2005) (see Appendix I for a comparison of the group distributions).

The Kolmogorov-Smirnov test for the coed girls' group yielded a significant result KS = .043, indicating a non-normal distribution. However, data for the other three

sample groups were normally distributed and analysis of variance is robust to violations of the normality assumption (Mertler & Vannatta, 2005). Group means and standard deviations are displayed in Figure 5.

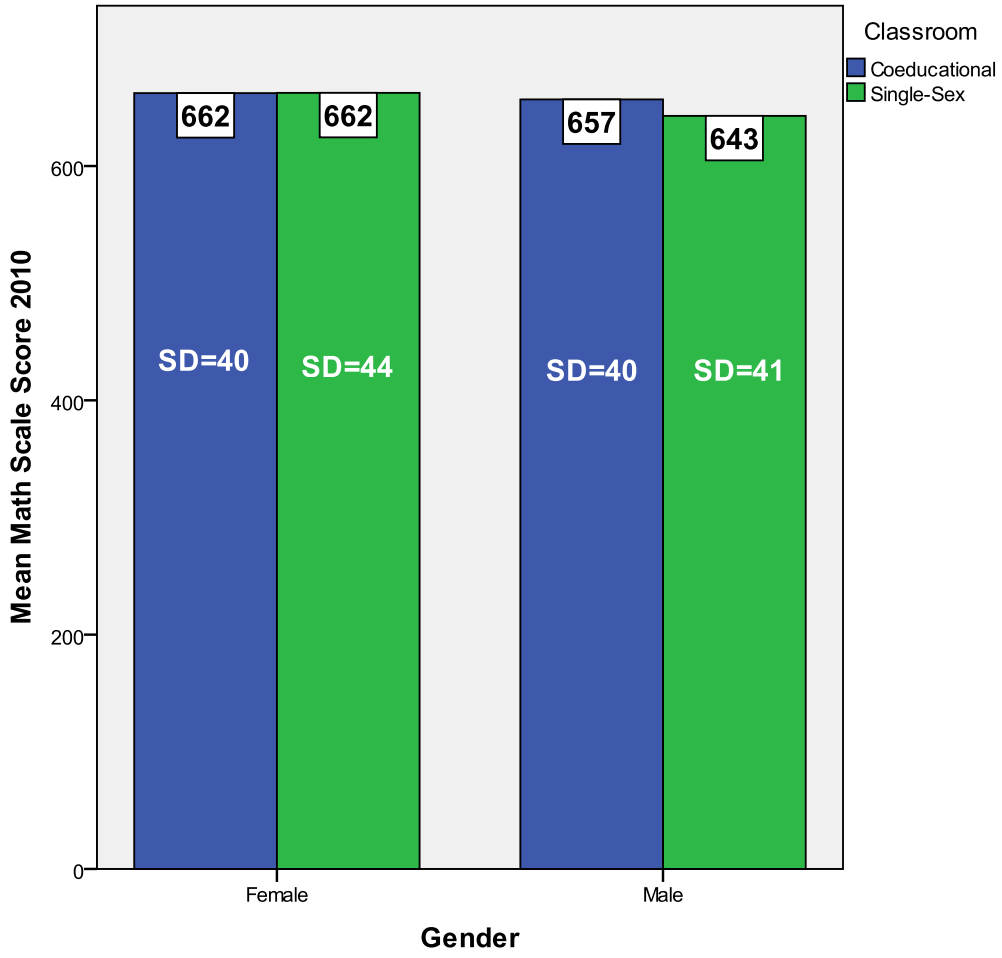

Figure 5. Fourth grade math problem solving means and standard deviations.

Levene's test of equality of variances was conducted within ANOVA and indicated homogeneity of variance across groups F (3, 160) = .08, p = .97. A line plot of gender and classroom placement indicated interaction between factors (see Appendix J).

A Univariate ANOVA was conducted to explore the impact of gender (male, female) and classroom placement (coeducational, single-sex) on math achievement as

measured by the math problem solving scaled scores from the Stanford Achievement Test Version 10 (SAT-10). The results of the ANOVA are displayed in Table 11.

Table 11

Fourth Grade Math ANOVA Results

Source	*SS*	*df*	*MS*	*F*	*P*	*ES*
Gender*Classroom	2084.33	1	2084.33	1.21	.273	.008
Gender	6423.19	1	6423.19	3.73	.055	.023
Classroom	1960.96	1	1960.96	1.14	.287	.007
Error	275477.52	160	1721.74			

While the line plot indicated interaction between gender and classroom placement, the interaction effect was not statistically significant, F (1, 160) = 1.21, p = .27. The main effect for gender, F (1, 160) = 3.73, p = .06, did not reach statistical significance. The main effect for classroom placement, F (1, 160) = 1.14, p = .29, did not reach statistical significance.

Hypothesis 6

No significant difference will exist by gender between fourth grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement. The population from which the sample was taken was normally distributed. Seven outliers were found within the sample groups. Outliers were recoded to the nearest score within the acceptable range (Mertler & Vannatta, 2005) (see Appendix K for a comparison of the group distributions).

Data for sample groups were normally distributed. Group means and standard deviations are displayed in Figure 6.

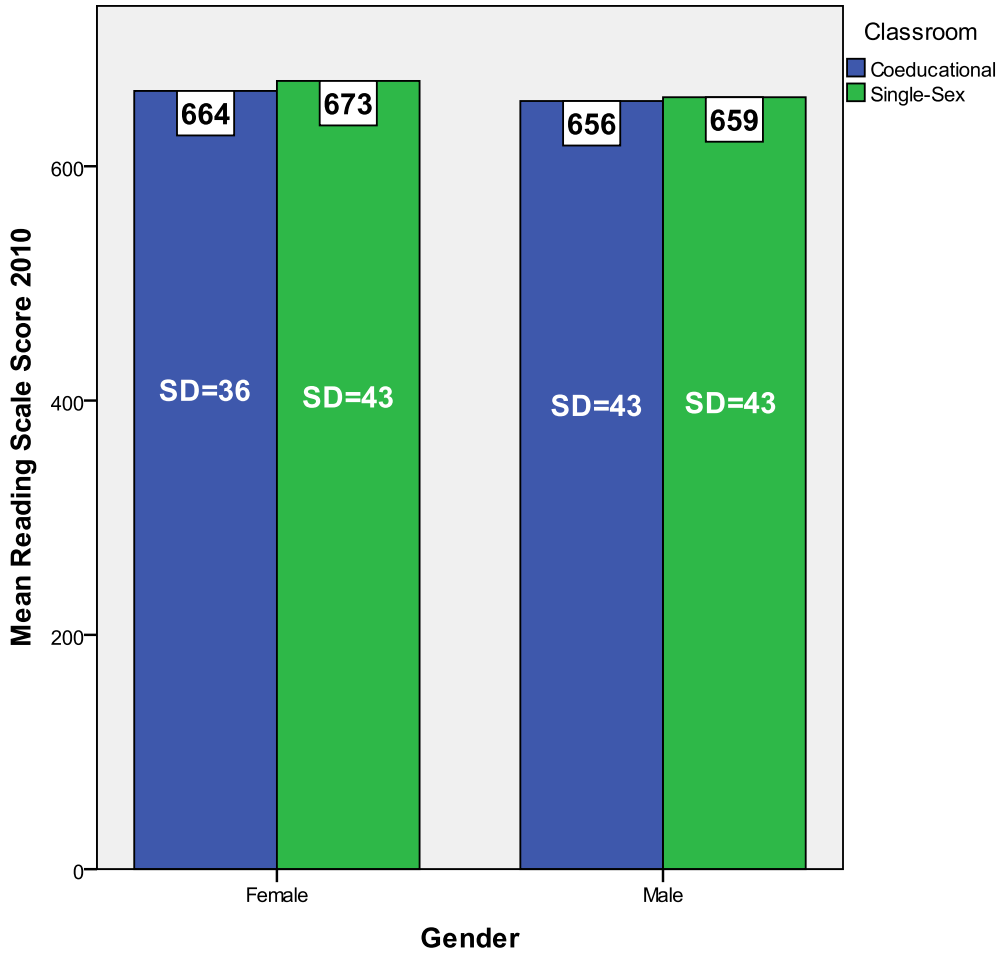

Figure 6. Fourth grade reading comprehension means and standard deviations.

Levene's test of equality of variances was conducted within ANOVA and indicated homogeneity of variance across groups F (3, 160) = .37, p = .77. A line plot of gender and classroom placement indicated no interaction between factors (see Appendix L).

A Univariate ANOVA was conducted to explore the impact of gender (male, female) and classroom placement (coeducational, single-sex) on reading achievement as measured by the reading comprehension scaled scores from the Stanford Achievement Test Version 10 (SAT-10). The results of the ANOVA are displayed in Table 12.

Table 12

Fourth Grade Reading ANOVA Results

Source	*SS*	*df*	*MS*	*F*	*p*	*ES*
Gender*Classroom	287.49	1	287.49	0.17	.681	.001
Gender	5194.76	1	5194.76	3.06	.082	.019
Classroom	1425.79	1	1425.79	0.84	.361	.005
Error	271917.96	160	1699.487			

The interaction effect between gender and classroom placement was not statistically significant, F (1, 160) = .17, p = .68. The main effect for gender, F (1, 160) = 3.06, p = .08, did not reach statistical significance. The main effect for classroom placement F (1, 160) = .84, p = .36, did not reach statistical significance.

CHAPTER V

DISCUSSION

Parents and students are asking for a greater variety of educational choices. Public education needs to look into all the possible ways to offer choice that will benefit student learning. The objective of this study was to contribute to the body of research in determining the academic effectiveness of single-sex education within an elementary school setting. Some public school advocates feel that single-sex education is a viable cost effective way to offer students and parents educational choice within the public school setting.

The focus of this study was to examine the effects of single-sex education on reading and math student achievement by gender for students in the second, third, and fourth grades in a rural Northwest Arkansas school district. A causal-comparative study was conducted and a sample was obtained by closely matching students taught in male and female single-sex classrooms with students in coeducational classrooms by gender, socioeconomic status, and previous math and reading assessment scores.

First, this chapter includes a reflection on the data collected and analyzed in this study. Second, recommendations based on the conclusions found in the data analysis are included for school administrators involved in the study as well as those interested in implementing a single-sex classroom program. Finally, the implications and significance of this study are discussed.

Conclusions

To address the first, third, and fifth hypotheses, three 2 x 2 factorial analysis of variances (ANOVAs) were conducted using classroom type (single-sex versus coeducational) and gender (male versus female) as the independent variables and math achievement as the dependent variable for the three different grade levels: second, third, and fourth, respectively. To address the second, fourth, and sixth hypotheses, three 2 x 2 factorial ANOVAs were conducted using classroom type (single-sex versus coeducational) and gender (male versus female) as the independent variables and reading achievement as the dependent variable for the three different grade levels: second, third, and fourth respectively. Main effects and interaction effects in each of the hypotheses were examined.

Hypothesis 1

Hypothesis 1 stated that no significant difference will exist by gender between second grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement. There was no significant interaction effect between the independent variables gender and classroom placement on the dependent variable math achievement measured by the SAT-10. Gender and classroom placement did not work together as a factor to influence math achievement. For the main effect of classroom type, no significant difference in math achievement was seen between students exposed to single-sex classrooms and those exposed to coeducational classrooms; however, a significant difference was found in math achievement for second grade students based on the main effect of gender. Based on these results, there was not enough evidence to reject the null hypothesis for the

interaction effect and the main effect of classroom type; however, there was enough evidence to reject the null for the main effect of gender.

Further, review of the data showed that second grade boys scored significantly higher in math achievement than girls. This statistically significant difference is not surprising; this result corresponds with the national trend that shows that boys tend to do better when compared to girls in math (Mead, 2006; OECD, 2001, 2009). Although this "typical" gender gap was seen at the second grade in math, there was not a significant gender difference, which favored boys in math, found at either of the other two grades studied in this project. A contributing factor might also have been that more boys than girls were identified as gifted students in this sample.

Both second grade single-sex classrooms had higher mean scores than their coeducational counter parts, but the differences did not reach statistical significance. Lack of statistical significance mirrors the findings of several research studies (Daly & Defty, 2004; Gibb et al., 2008; Gillis, 2005; Hopkins, 2001; Spielhagen, 2008). The lack of statistical significance could be attributed to the newness of the program itself in these schools. During this first year of single-sex classes, teachers and students spent time adjusting to the classroom changes from a coeducational classroom to a single-sex classroom. Single-sex classroom teachers developed strategies throughout the year on how best to teach to each of the genders. This was a new situation for everyone involved.

Hypothesis 2

Hypothesis 2 stated that no significant difference will exist by gender between second grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement.

There was no significant interaction between the independent variables gender and classroom placement on the dependent variable reading achievement measured by the SAT-10. Gender and classroom placement did not work together as a factor to influence reading achievement. For the main effect of classroom type, no significant difference in reading achievement was seen between students exposed to single-sex classrooms and those exposed to coeducational classrooms regardless of gender. In addition, the data showed no significant difference in reading achievement for second grade students based on the main effect of gender. Based on these results, there was not enough evidence to reject the null hypothesis on the interaction effect and the two main effects.

Research identified a literacy gender gap favoring girls to be a nationwide tendency (Mead, 2006; OECD, 2001, 2009). This typical gender gap was not seen in the area of reading achievement at the second grade in this study. Although the difference was not significant, overall, boys in this second grade study had higher mean scores than girls, which was an unexpected result. A contributing factor might be the fact that more boys than girls in this sample were identified as gifted students.

Although no statistically significant differences existed by classroom placement, in this case, the second grade single-sex girls' classroom had a higher mean score than the coeducational class, and the coeducational boys' class had a higher mean score than the single-sex boys' class. These results might reflect a statement made by Whitmore (2005) that indicated that in the area of literacy, boys might best benefit from placement in a coeducational class with more girls than boys before the third grade.

Hypothesis 3

Hypothesis 3 stated that no significant difference will exist by gender between third grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement. No significant interaction was found between the independent variables gender and classroom placement on the dependent variable math achievement measured by the SAT-10. Gender and classroom placement did not work together as a factor to influence math achievement. For the main effect of classroom type, no significant difference in math achievement was seen between students exposed to single-sex classrooms and those exposed to coeducational classrooms. In addition, the data showed no significant difference in math achievement for third grade students based on the main effect of gender. Based on these results, there was not enough evidence to reject the null hypothesis on the interaction effect and the two main effects.

Research identified the fact that boys generally perform better in mathematics than girls (Geist & King, 2008; OECD, 2009). In this study, a gender gap favoring boys was not seen in the area of math achievement at the third grade. Overall, the girls in this study had slightly higher mean scores than boys. This was an unexpected difference, suggesting that more data might need to be collected and analyzed to identify factors that might be contributing to closing the typical math gender gap. A contributing factor might be that more girls than boys in this sample were identified as gifted students.

There was no difference between the mean scores of third grade boys participating in single-sex classes compared to third grade boys participating in coeducational classes. Although not significantly different, girls in coeducational classes

had a slightly higher mean score than girls in the single-sex classes. These are the same results reported by Gillis (2005) in a study of a school in their first year of implementing single-sex classrooms where it was found that there was no difference between boys and girls math achievement based on their classroom placement (single-sex versus coeducational). The results of this study also correspond with the findings of Hopkins (2001) who found no significant differences in mathematics scores for girls in coeducational classes compared to those in single-sex classes.

Hypothesis 4

Hypothesis 4 stated that no significant difference will exist by gender between third grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement. There was no significant interaction between the independent variables gender and classroom placement on the dependent variable reading achievement measured by the SAT-10. Gender and classroom placement did not work together as a factor to influence reading achievement. For the main effect of classroom type, no significant difference in reading achievement was seen between students exposed to single-sex classrooms and those exposed to coeducational classrooms; however, data analysis identified a significant difference in reading achievement for third grade students based on the main effect of gender. Based on these results, there was not enough evidence to reject the null hypothesis for the interaction effect and the main effect of classroom type; however, there was enough evidence to reject the null for the main effect of gender.

The results showed that the third grade girls participating in this study scored significantly higher in reading than boys. These results reflect the national trends, where

generally, girls perform better with literacy than boys (Mead, 2006; OECD, 2001, 2009). Support for this comes from the fact that during the elementary years, the female brain is rapidly developing language skills (Gurian & Ballew, 2003; Sax, 2005). Another contributing factor might be that more girls than boys in this sample were identified as gifted students.

Overall, the third grade coeducational classes scored better than their single-sex counterparts did in this study; however, differences were very small and not significant. These results correspond with the work of Spielhagen (2008); she noted that both sixth and seventh grade single-sex and coeducational girls made gains from the previous year in the area of reading. In that study, however, the coeducational girls made the greater gains. Other research has yielded mixed results (U.S. Department of Education, 2008).

Hypothesis 5

Hypothesis 5 stated that no significant difference will exist by gender between fourth grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on math achievement. There was no significant interaction between the independent variables gender and classroom placement on the dependent variable math achievement measured by the SAT-10. Gender and classroom placement did not work together as a factor to influence math achievement. For the main effect of classroom type, no significant difference in math achievement was seen between students exposed to single-sex classrooms and those exposed to coeducational classrooms. In addition, the data showed no significant difference in math achievement for fourth grade students based on the main effect of

gender. Based on these results, there was not enough evidence to reject the null hypothesis on the interaction effect and the two main effects.

It was again interesting that a gender gap favoring boys was not seen in the area of fourth grade math achievement. Although not significant, the girls in this fourth grade study had slightly higher mean scores than the boys did. Generally, boys perform better in mathematics than girls. This was an unexpected shift, suggesting that more data might need to be collected and analyzed to identify factors that might be contributing to closing the typical math gender gap.

The mean scores for the girls in both fourth grade classroom placements were identical. Although not significant, the fourth grade boys in the coeducational classrooms scored higher than the boys did in the single-sex classrooms. It is not unusual for any statistical difference to be seen between single-sex classrooms and coeducational classrooms (Daly & Defty, 2004; Gibb et al., 2008; Spielhagen, 2008).

Hypothesis 6

Hypothesis 6 stated that no significant difference will exist by gender between fourth grade students in a Northwest Arkansas school who are exposed to single-sex classrooms and those exposed to coeducational classrooms on reading achievement. There was no significant interaction between the independent variables gender and classroom placement on the dependent variable reading achievement measured by the SAT-10. Gender and classroom placement did not work together as a factor to influence reading achievement. For the main effect of classroom type, no significant difference in reading achievement was seen between students exposed to single-sex classrooms and those exposed to coeducational classrooms. In addition, the data showed no significant

difference in reading achievement for fourth grade students based on the main effect of gender. Based on these results, there was not enough evidence to reject the null hypothesis on the interaction effect and the two main effects.

Although fourth grade girls had higher mean reading scores than the boys did in this study, a significant gender gap was not noted. The review of literature identified a widespread gender gap favoring girls in the area of literacy (Mead, 2006; Mullis et al., 2007; OECD, 2001, 2009). More data should be collected and analyzed to see what might be contributing to closing this gender gap in literacy.

Although both fourth grade single-sex classes had slightly higher mean scores than their coeducational counterparts, there is no evidence that single-sex classrooms make a significant difference. This result corresponds to the 2008 findings of the U.S. Department of Education's study where 53% of the studies neither favored coeducational nor single-sex classrooms.

Recommendations

The results of this study indicated that classroom placement by gender and classroom placement as a main effect did not make a significant difference in reading or math achievement during the first year of implementation of single-sex classrooms at three grade levels in a rural school district in Arkansas. These results correspond with the majority of findings in the 2008 U.S. Department of Education's systematic review of literature. In this report, 53% of the studies of single-sex schools were inconclusive, neither favoring single-sex education nor coeducation. Therefore, the first recommendation is that the program be continued and expanded to other grades to assess

the effects of single-sex classes within an established program and to study the long-range effects of single-sex classrooms.

During the first year of implementation, teachers experienced a high learning curve, as they worked to meet the learning needs of their students based on gender tendencies. Both the teachers and the students had to adjust to the transition from coeducational classrooms to single-sex classrooms. During the second year, teachers will be able to build upon their prior knowledge and ultimately be more successful meeting student needs and increasing student achievement. A second year of implementation with students continuing in single-sex classrooms may better represent the potential benefits of the program because students, parents, and teachers all know what to expect from the beginning of the school year.

To assess the benefits of the program, it is important not only to continue to offer single-sex classrooms at the current grade levels, but to extend the program to the fifth grade. Students should be studied over time to see if single-sex classroom placement has a cumulative effect on student achievement. Does the time length of student participation in the program strengthen the effect the program has on student achievement? With no significant negative student achievement effects found in this study based on classroom placement, it makes sense to again offer parents and students classroom placement choices and extend the program to the next grade.

A second recommendation is to continue professional development on understanding gender differences. The review of literature suggests that professional development is an important factor in the success of single-sex programs (Gurian & Ballew, 2003; Sax, 2005). There was limited opportunity for formal professional

development during this initial implementation year. Continued professional development should provide teachers with more tools to be successful in teaching both girls and boys. At the beginning of this single-sex program, teachers attended one day of training with a Gurian Institute trainer. It is suggested that teachers continue the training started with the Gurian Institute.

Significant gender gaps seen in second grade math and third grade reading in this research project follow the stereotypical ideas and national data discussed in the review of literature (Mead, 2006), which indicated that boys do better in math and girls do better in literacy. However, it is interesting that this trend was not seen at all three grade levels. A significant gender gap might indicate a need to extend professional development on understanding gender differences to teachers of coeducational classes as well as teachers of single-sex classes.

Because all coeducation teachers work with students of both genders, they would benefit from a better understanding of gender tendencies. If one's goal were to make all students successful, a better understanding of the learning differences between the boys and girls would give all teachers more insight in how to individualize learning for students and maximize each student's potential.

In addition, more research should be done to identify factors that might be contributing to closing gender achievement gaps that are typically seen nationwide. What is happening at the grade levels to contribute to the closing or reversal of the typical gender gaps, where girls are outscoring boys in math and boys are outscoring girls in reading?

This study only looked at the student achievement aspect of the classroom. A third recommendation is that future studies focus on achievement and other types of data such as discipline and attendance as well as the qualitative aspects of the classroom such as student self-esteem and self-confidence. Teacher responses to teaching in a single-sex environment versus a coeducational environment and student satisfaction with being in a single-sex classroom versus a coeducational environment would also merit attention. Finally, parent satisfaction with classroom placement should also be studied.

The 2003 U.S. Department of Education Institute of Education Sciences guide to indentifying educational practices that are supported by rigorous evidence states that for an intervention to be backed by strong evidence, the research should include randomized controlled trials. It is difficult to provide this type of research within schools. When randomization is not possible, research studies should include comparison groups that are matched closely in achievement and demographics. A strength of this research project was that samples were closely matched comparison groups. Continued research projects should be done comparing single-sex classes and coeducational classes using either randomization or closely matched groups.

Implications

Significance and Expansion of Knowledge Base

The first implication of this study is that significant differences in achievement based on classroom placement may not be evident during the first year of implementing single-sex classrooms. Change theory indicates that the initial stages of implementing change will include an implementation dip and a possible drop in performance (Fullan, 2001). Although this study suggests that during the first year of implementing single-sex

classes a significant implementation dip did not occur, it will be important to check these results with other districts initiating similar programs. However, these findings should be encouraging to other districts thinking about starting a single-sex program as a way of offering students and parents educational choice.

This study had several strengths. One strength was that it used closely matched pairs of participants. Another strength of this research was that at each grade level, students in both the single-sex and coeducational classes were exposed to all of the same external environmental factors. Student were taught the same curriculum, housed in the same school, and exposed to the same district and building-wide initiatives. The results of this research add to the growing body of research on single-sex classrooms within coeducational schools and extend the available research on single-sex education within an elementary school setting. This study can serve as a springboard for future studies.

Future Research Considerations

Although the focus of this study was student achievement, it is important to look at all aspects of the classroom when assessing the benefits of a program. Future researchers might build upon this study by researching the qualitative aspects of the classroom such as student self-esteem, self-confidence, classroom satisfaction, discipline, and attendance rates. A mixed methods approach might provide a more detailed picture of the overall effectiveness of the single-sex classrooms by offering a more inclusive look at the many factors that affect student achievement within a classroom.

More studies of single-sex classrooms need to be conducted at elementary public schools. Much of the available research has been focused on middle school and high school private single-sex schools (American Institutes for Research, 2004; U.S.

Department of Education, 2005). Not enough is known about the effects of single-sex classrooms within a public school setting, specifically at the elementary level. Sax (2005) stated that if educators understood gender issues better, fewer boys might be referred for Attention Deficit Disorders (ADD) and special education in the early elementary school years. A better understanding of young boy behavior and brain development might help teachers better understand these behaviors and see them as normal instead of seeing them as reasons to make referrals for special services. Focusing boy behaviors in a positive direction can increase the probability of success for boys in school.

Hughes (2006) related that some research studies indicate that minority and low socioeconomic students benefit most from a single-sex environment. More studies need to focus on the effects of race and socio-economic status on student achievement in single-sex classrooms.

Potential Policy Changes

At the national level, lawmakers opened the door for single-sex education within the public school setting through No Child Left Behind legislation and revisions in Title IX (Cable & Spradlin, 2008). Changes at the national level were made to encourage innovative educational methods such as single-sex classrooms. South Carolina has developed an educational innovation division within their state department of education to support schools wanting to implement single-sex classroom programs (South Carolina Department of Education, 2008). This division also collects data and does research to assess the effectiveness of these programs on student achievement. Other states should consider taking a similar approach to supporting educational innovations such as single-sex education in public schools.

First, states might offer support in several different forms such as but not limited to offering grants to schools wanting to implement innovative programs. There are always costs to initiating a program. Grant funds might help provide time for collaboration, professional development, or materials. Small grants might provide the incentive for a school to step out and take a risk with an innovative idea. Second, another support might be to provide a search engine for identifying schools with successful innovative programs. Along with a search engine, a social networking system could be set up to allow schools to contact and support each other online during the implementation process. States could provide conferences to highlight innovative school initiatives to identify and reward schools with successful innovative programs. A conference set up is a good place for people interested in new ideas to come, hear a variety of ideas, and identify those approaches that might best fit their district or school situation.

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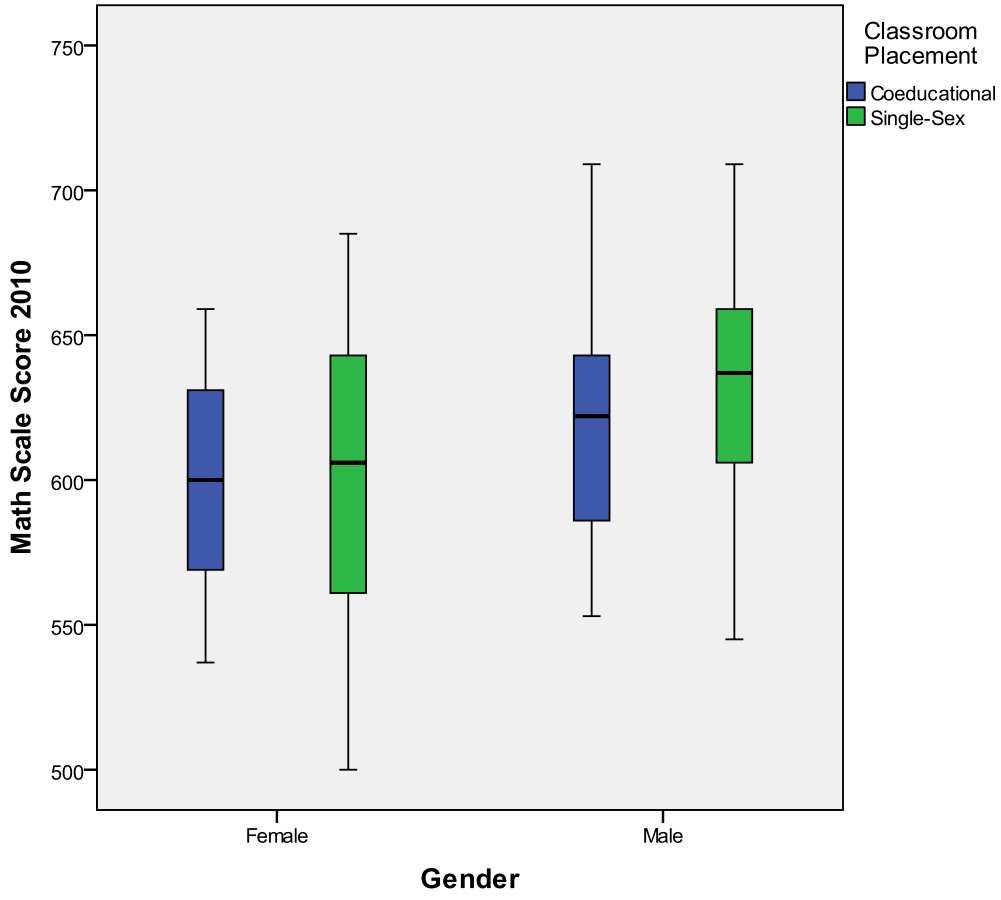
APPENDICES

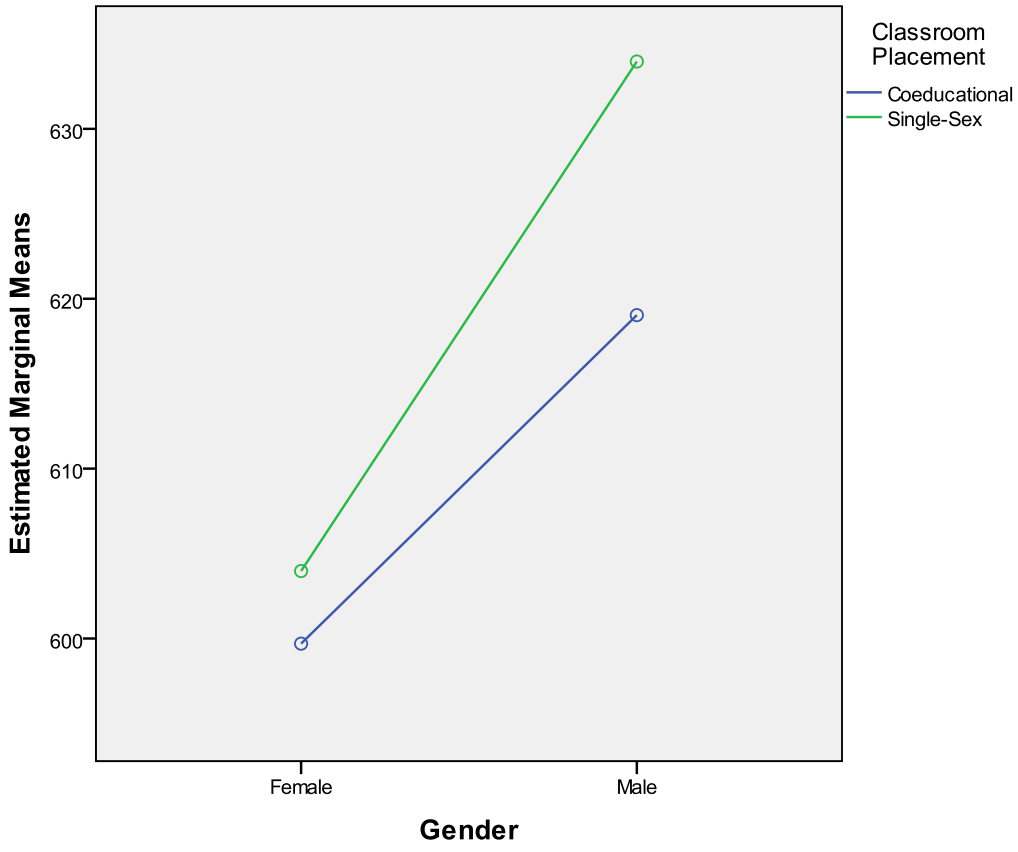
APPENDIX A

Second Grade Math Group Scale Score Comparison



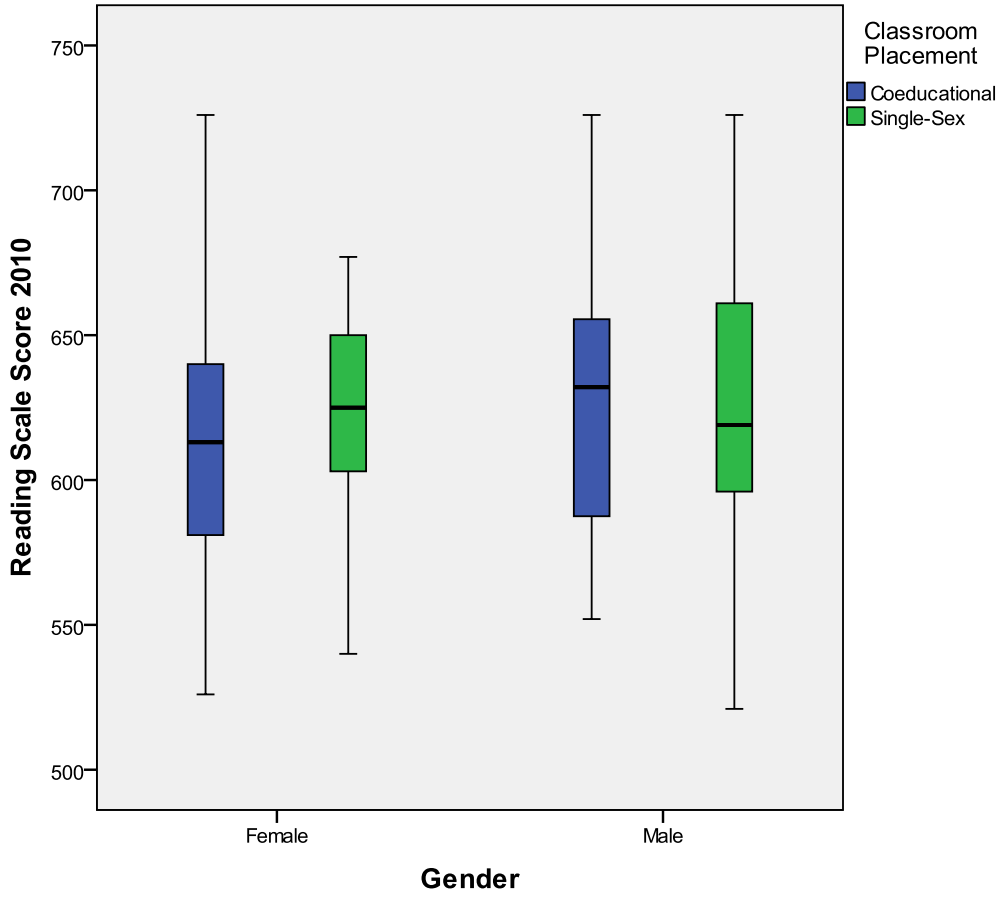
APPENDIX B

Second Grade Estimated Marginal Means of Math Scale Scores



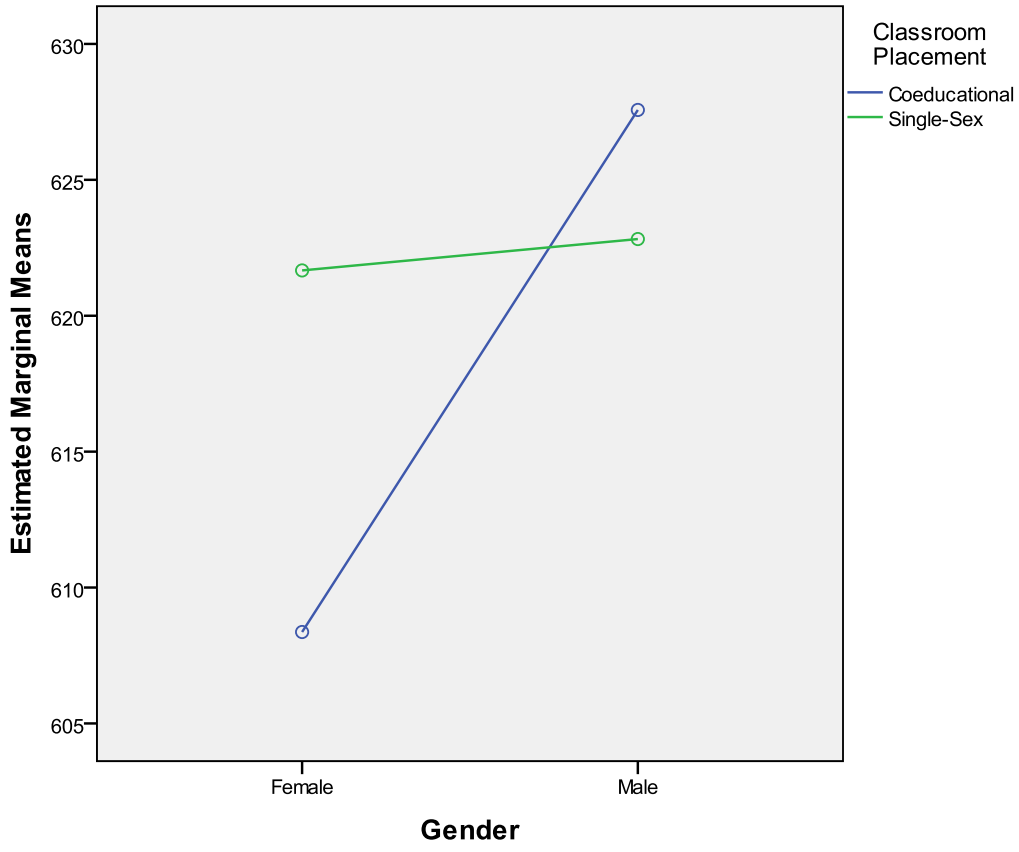
APPENDIX C

Second Grade Reading Group Scale Score Comparison



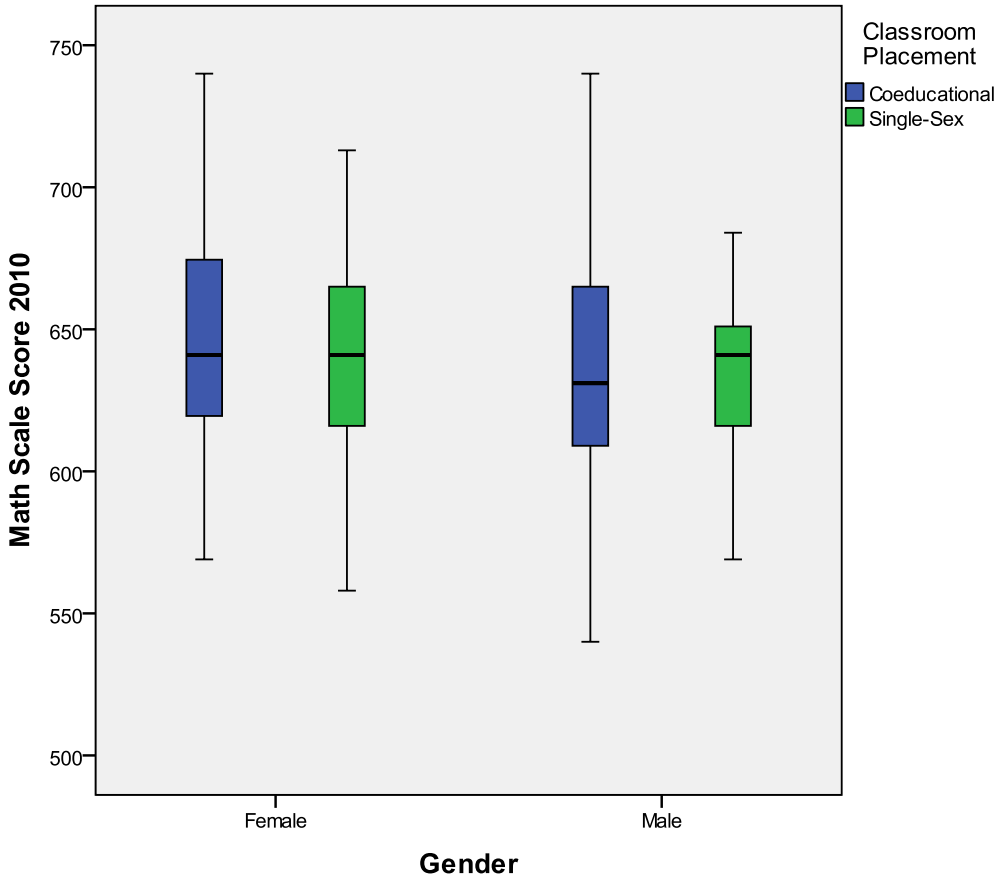
APPENDIX D

Second Grade Estimated Marginal Means of Reading Scale Scores



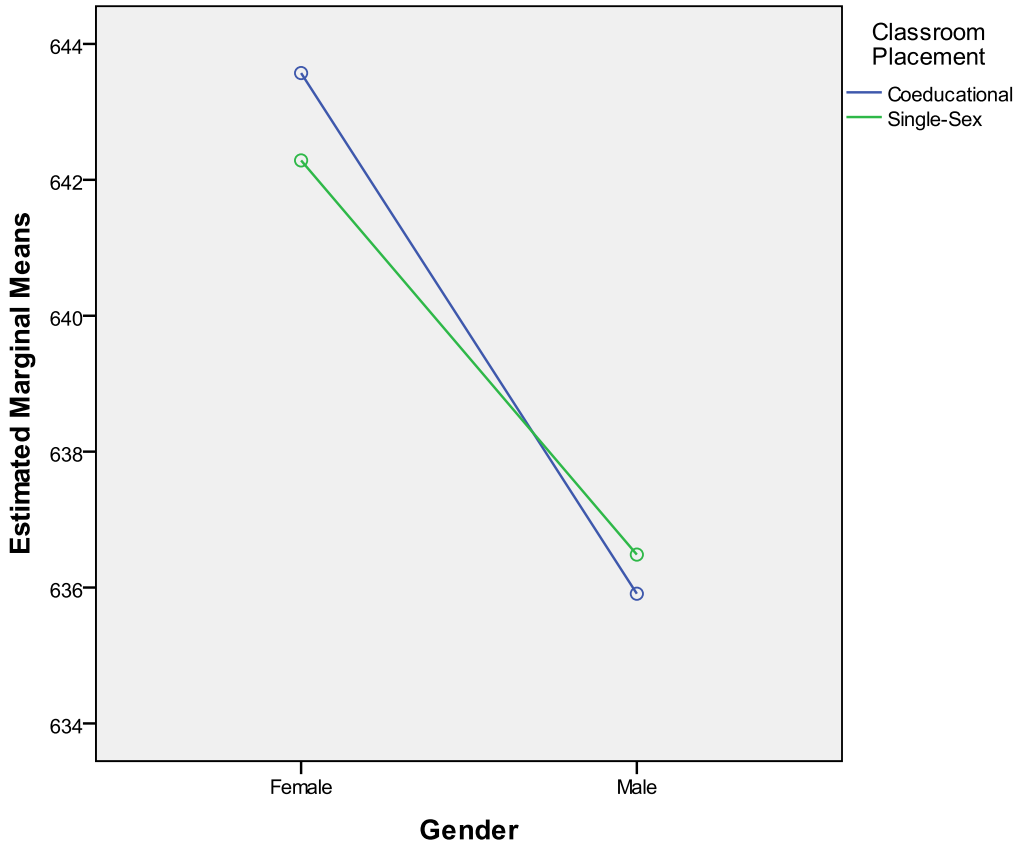
APPENDIX E

Third Grade Math Group Scale Score Comparison



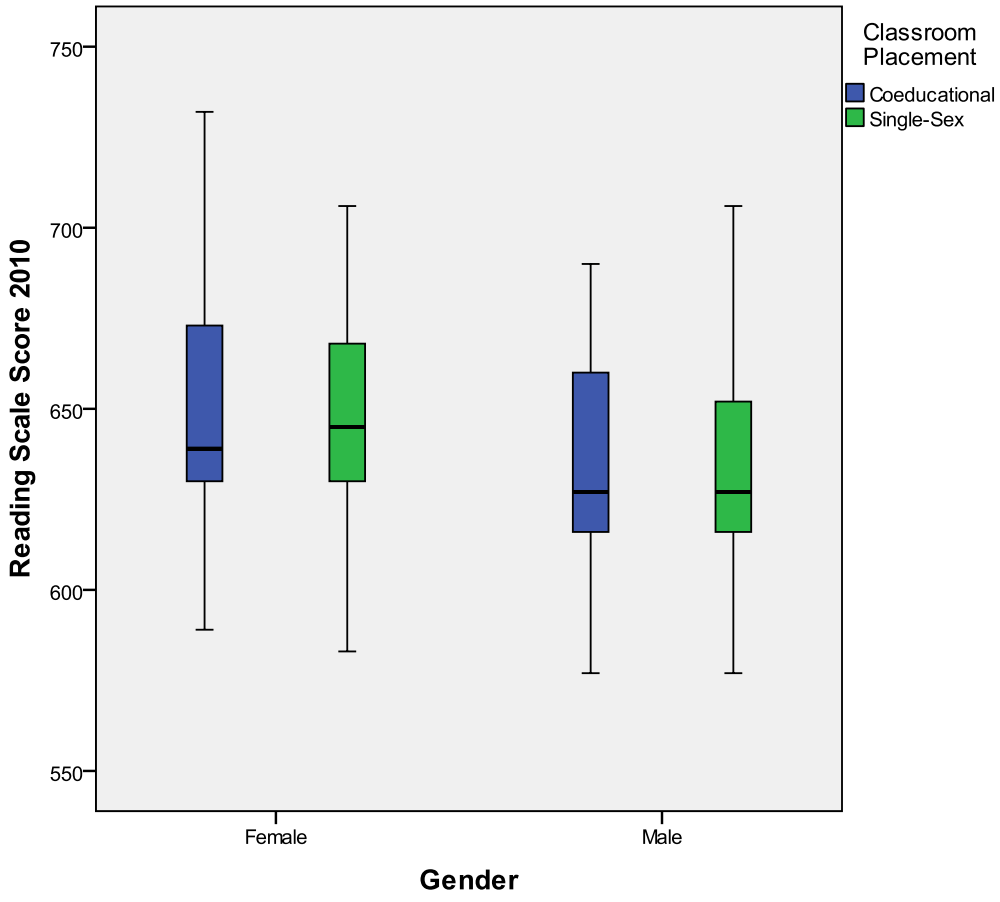
APPENDIX F

Third Grade Estimated Marginal Means of Math Scale Scores



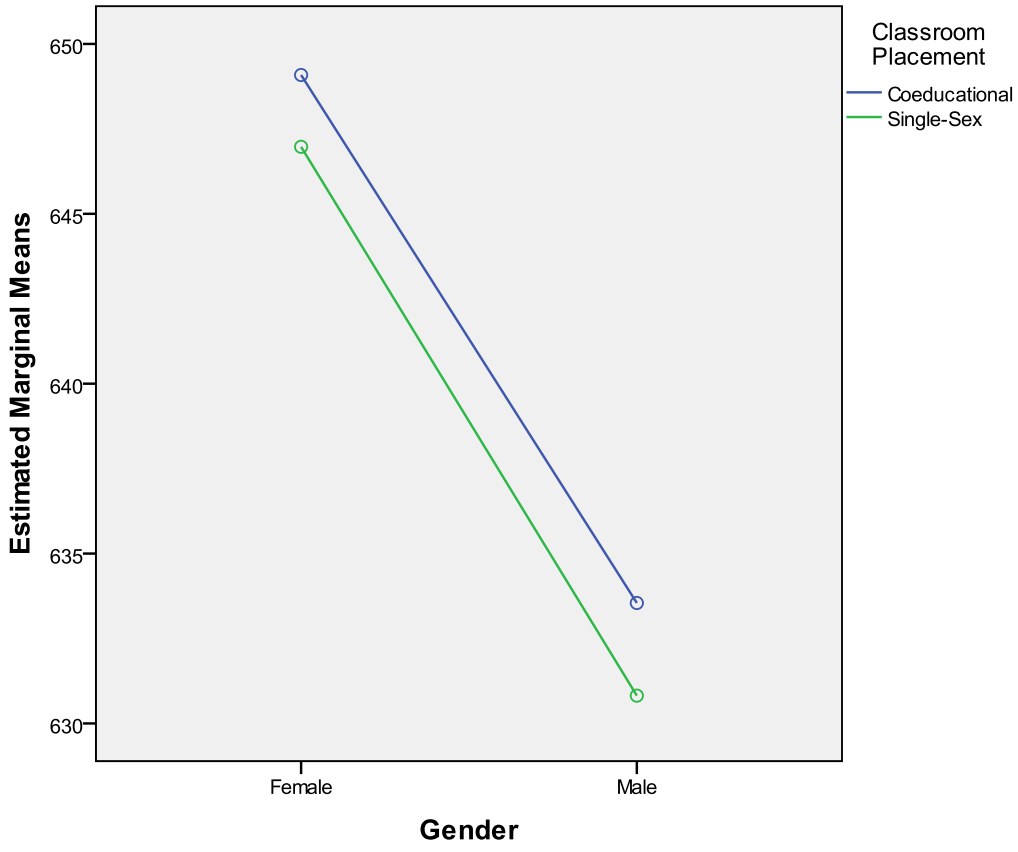
APPENDIX G

Third Grade Reading Group Scale Score Comparison



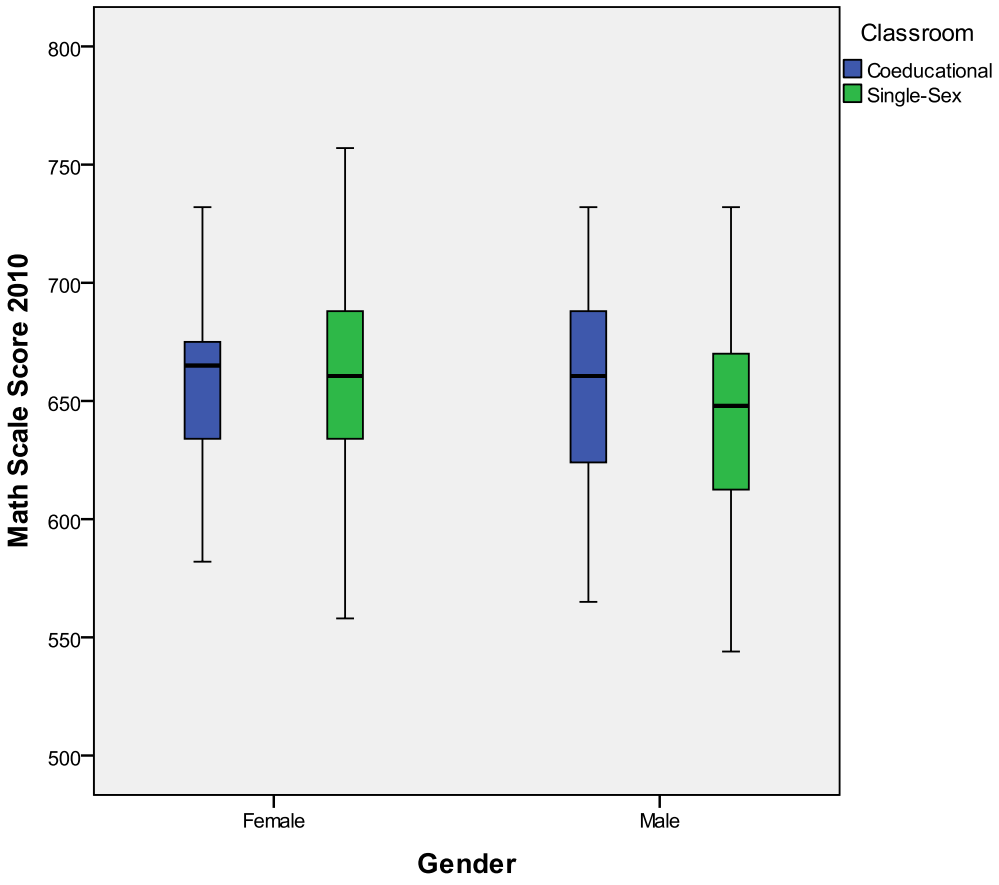
APPENDIX H

Third Grade Estimated Marginal Means of Reading Scale Scores



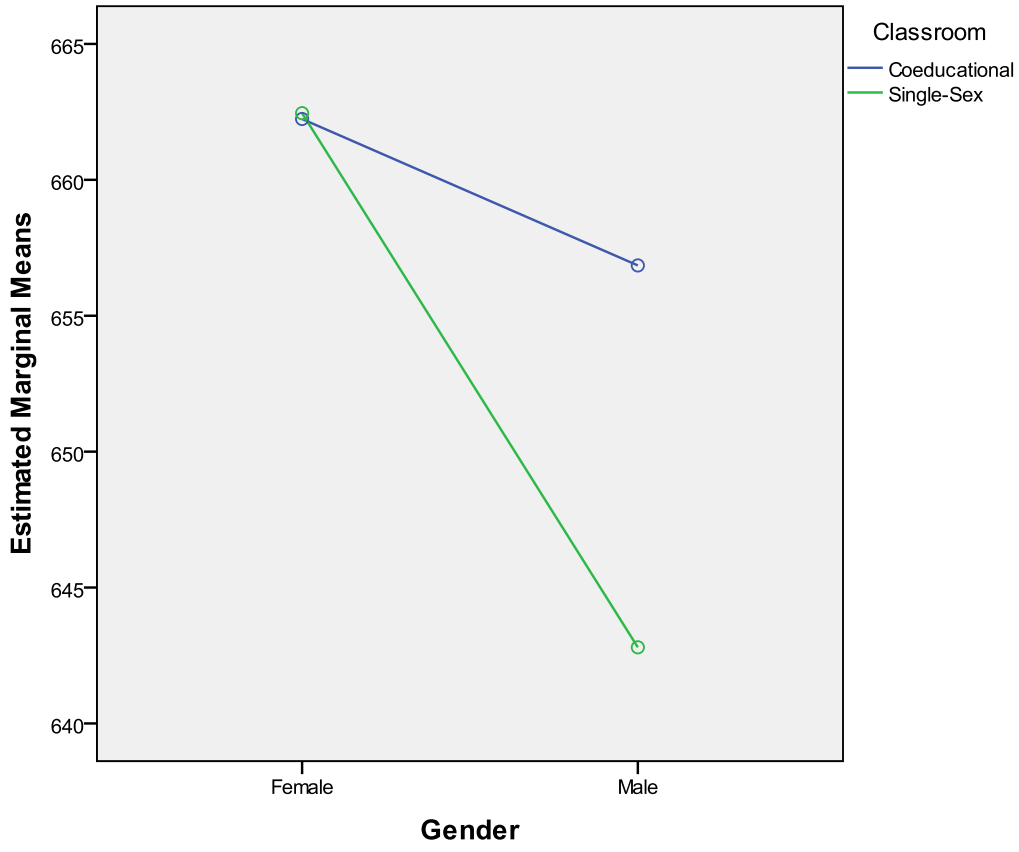
APPENDIX I

Fourth Grade Math Group Scale Score Comparison



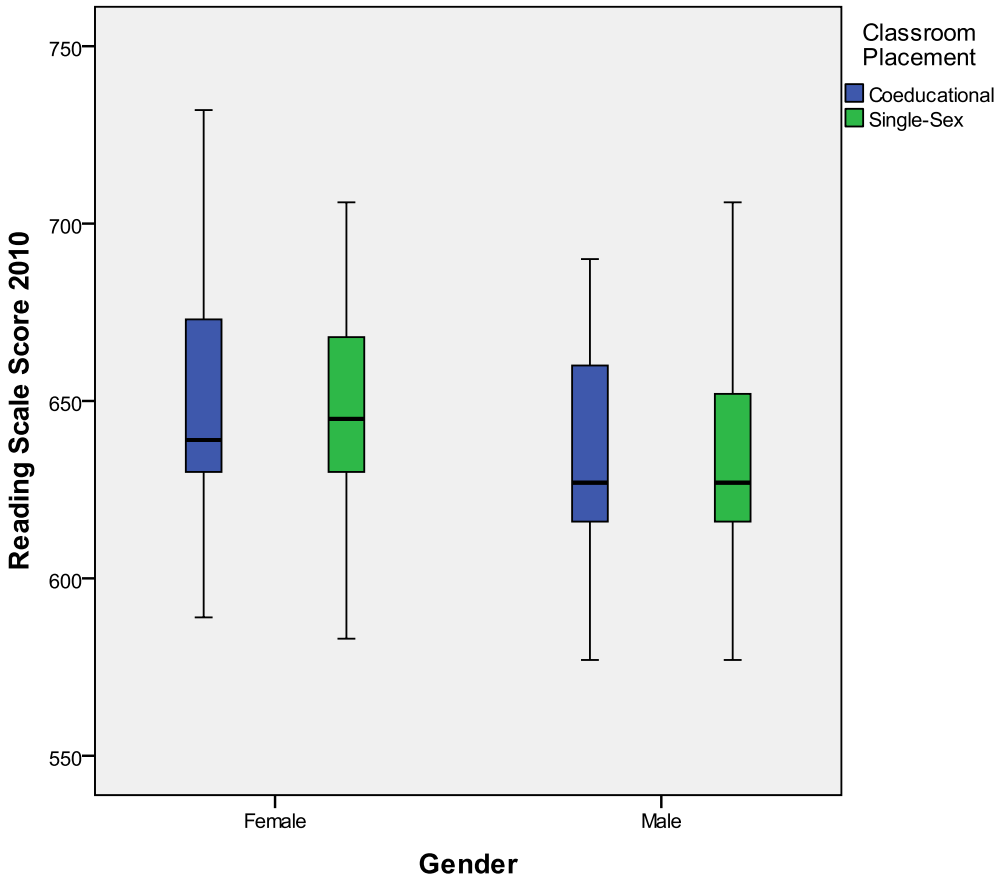
APPENDIX J

Fourth Grade Estimated Marginal Means of Math Scale Scores



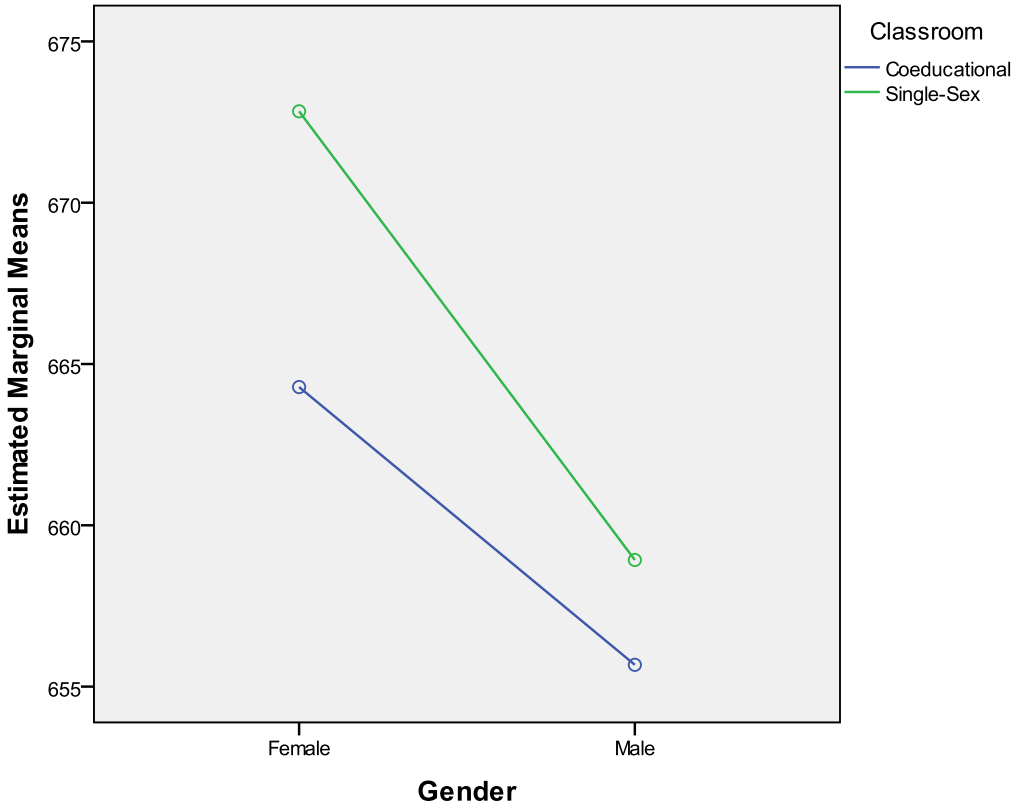
APPENDIX K

Fourth Grade Reading Group Scale Score Comparison



APPENDIX L

Fourth Grade Estimated Marginal Means of Reading Scale Scores



APPENDIX M

Status of Request for Expedited Review

Status of Request for Expedited Review

(For Board Use Only)

Date: February 2, 2010

Proposal Number: 2010-03

Title of Project: Effects of Single-Sex Classrooms versus Co-educational Classrooms on Math and Literacy Achievement

Principal Investigator(s) and Co-Investigator(s): Constance D. Matchell

☐ Research approved.

■ Approved with modifications, as provided in January 22, 2010 submission.

☐ Committee requests further information before a decision can be made.

☐ This proposal has been denied.

I have considered your request for an **expedited review**, and my decision is marked above. Please review the appropriate text below for the decision that was rendered regarding your proposal:

Research Approved: If your protocol has been approved, please note that your project has IRB approval from today for a period of one year and you are free to proceed with data collection. If this study continues unchanged for longer than one year, you will need to submit a ***Request for Project Continuation***. If there are changes to the research design or data that is collected, you will need to submit a ***Request for Amendment to Approved Research*** form. The IRB reserves the right to observe, review and evaluate this study and its procedures during the course of the study.

Approved with Modifications: If approved with modifications, you are allowed to proceed with data collection provided that the required modifications are in place. If this study continues unchanged from that amended protocol for more than one year, you will need to submit a ***Request for Project Continuation***. If this study continues for more than one year and there are changes to the research design or data that is collected, you will need to submit a ***Request for Amendment to Approved Research*** form.

Committee requests further information: Please see the attached document and use it to guide required modifications, then re-submit your request.

This proposal has been denied: See the attached document for an explanation of why your proposal has been denied.

Chair, Harding University Institutional Review Board